MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

Vol. XLVII MARCH-APRIL, 1955 No. 2

CONTENTS

Growth substance requirements of Stereum Murraii
WILLIAM J. ROBBINS AND ANNETTE HERVEY 155

The development of the ascocarp in Pseudoplea Gaeumannii
LEWIS E. WEHMEYER 163

Gametogenesis and oospore formation in Sclerospora species on Sorghum vulgare
K. M. SAFEEULA AND M. J. THIRUMALACHAR 177

Resting spore germination in Synchytrium australe in relation to its classification ..... JOHN S. KARLING 185

The genus Circinella
C. W. HESSELTINE AND DOROTHY I. FENNELL 193

Perennial polypores of North America III. Fomes with context white to rose ..... JOSIAH L. LOWE 213

Species of Puccinia on Salvia in Europe, Asia and Africa
JOHN W. BAXTER 225

A new species of Penicillium from soil
PHILIP A. ORPURT AND DOROTHY I. FENNELL 233

A reclassification of the genus Pericystis Betts
CHARLES F. SPILTOIR AND L. S. OLIVE 238

A new species of Stylopage capturing nematodes
C. L. DUDDINGTON 245

Some leafspot fungi on western Gramineae—VIII
RODERICK SPRAGUE 249

Vera K. Charles ..... EDITH K. CASH 263

Notes and Brief Articles 266

[MYCOLOGIA for January-February (47: 1-154) was issued March 8, 1955]

PUBLISHED BIMONTHLY FOR

THE NEW YORK BOTANICAL GARDEN

AT PRINCE AND LEMON STS., LANCASTER, PA.

Entered as second-class matter April 30, 1925, at the post office at Lancaster, Pa., under the Act of August 24, 1912.

MYCOLOGIA

Published by

THE NEW YORK BOTANICAL GARDEN

IN COLLABORATION WITH THE

MYCOLOGICAL SOCIETY OF AMERICA

OFFICERS OF THE MYCOLOGICAL SOCIETY OF AMERICA

WILLIAM W. DIEHL, *President*
Plant Industry Station

RALPH EMERSON, *President-elect*
University of California

JOSIAH L. LOWE, *Vice-President*
Syracuse University

C. J. ALEXOPOULOS, *Sec.-Treas.*
Michigan State College

LINDSAY S. OLIVE, *Councilor*, 1954–55
Columbia University

G. A. LEDINGHAM, *Councilor*, 1954–55
Prairie Regional Laboratory

LELAND SHANOR, *Councilor*, 1955–56
University of Illinois

CHARLES GARDNER SHAW, *Councilor*, 1955–56
Washington State College

DONALD P. ROGERS, *Historian*
New York Botanical Garden

EDITORIAL BOARD

G. W. MARTIN, *Editor-in-Chief*
State University of Iowa
Box 336, Iowa City, Iowa

DONALD P. ROGERS, *Managing-Editor*
New York Botanical Garden
Bronx Park, New York 58, N. Y.

EDITH K. CASH, '55
Plant Industry Station, Beltsville, Maryland

C. W. EMMONS, '56
National Institute of Health
Bethesda 14, Maryland

F. L. DRAYTON, '57
Department of Agriculture, Ottawa, Canada

H. L. BARNETT, '58
West Virginia University, Morgantown, W. Va.

ALMA WHIFFEN BARKSDALE, '59
New York Botanical Garden, Bronx Park, New York 58, N. Y.

SUSTAINING MEMBERS

Abbott Laboratories
The American Sterilizer Company
Baltimore Biological Laboratory, Inc.
Ben Venue Laboratories, Inc.
Buckman Laboratories, Inc.
Cutter Laboratories
Difco Laboratories
E. I. Dupont de Nemours & Company
Heyden Chemical Corporation
Keystone Mushroom Co.
Lederle Laboratories
Eli Lilly Company
Chas. Pfizer & Co., Inc.
E. R. Squibb and Sons
Standard Brands, Inc.
The Arthur H. Thomas Company
The Wallerstein Company

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

XLVII MARCH–APRIL, 1955 No. 2

GROWTH SUBSTANCE REQUIREMENTS OF STEREUM MURRAII [1]

WILLIAM J. ROBBINS AND ANNETTE HERVEY

(WITH 3 FIGURES)

Stereum Murraii Burt grows poorly on a basal medium of asparagine, mineral salts and dextrose.[2] Its growth is much improved by adding natural materials such as malt extract, to the basal medium. We have been concerned with determining why media containing natural materials are superior to the basal medium for the growth of this fungus.

MATERIALS AND METHODS

The strain of *S. Murraii* was obtained from Ross W. Davidson under his number *71162*. All glassware was cleaned with chromic acid followed by thorough rinsing with tap and distilled water. In some experiments the fungus was grown on a medium solidified with purified agar (Robbins and Ma, **1945**). Dry weights for liquid cultures were obtained by treating the mycelium with ethanol, filtering into Gooch crucibles, washing with distilled water and drying at 100° C. The fungus was grown at approximately 25° C.

[1] This investigation was supported in part by a grant from The American Agricultural Chemical Company.

[2] Basal medium No. 1 contained per liter 1.5 g KH_2PO_4, 0.5 g $MgSO_4 \cdot 7H_2O$, 2.0 g asparagine, 50.0 g dextrose. Mineral supplements were added as follows: 0.01 ppm B, 0.04 ppm Cu, 0.2 ppm Fe, 0.02 ppm Ga, 0.02 ppm Mn, 0.02 ppm Mo and 0.18 ppm Zn.

[MYCOLOGIA for January–February (**47**: 1–154) was issued March 8, 1955]

EFFECT OF VARIOUS NATURAL MATERIALS

The beneficial effect of the addition of 1.25 percent malt extract to the basal medium was marked. Coconut milk which had been concentrated to 0.1 its volume by evaporation was equally effective on a dry weight basis, as judged from growth on agar slants. Peptone at 0.0125 percent was somewhat beneficial, but injurious at 1.25 percent. Hydrolyzed gelatin (Eastman purified calf skin) was ineffective at 0.0125 percent and somewhat injurious at 1.25 percent (FIG. 1). "Vitamin free" casein hydrolysate was ineffective. The addition of a mixture of B

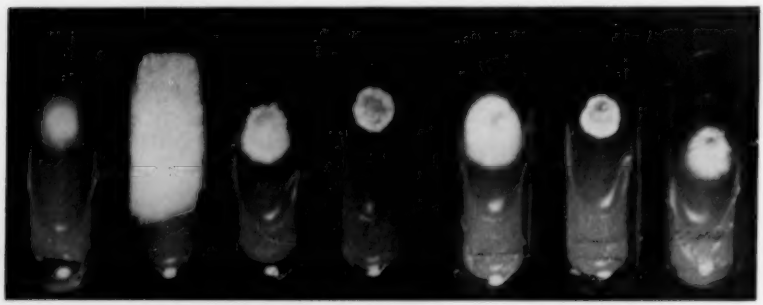


FIG. 1. Effect of malt extract, peptone and gelatine hydrolysate on growth of *Stereum Murraii* on basal agar medium containing mineral salts, dextrose, and asparagine. Cultures 48 days old.

Left to right. Basal medium; plus 100 mg malt extract per tube; plus 1 mg malt extract; 100 mg peptone; 1 mg peptone; 100 mg hydrolyzed gelatine; 1 mg hydrolyzed gelatine.

vitamins [3] was slightly beneficial, but a combination of B vitamins and casein hydrolysate was far more effective.

RELATION TO THIAMINE

The omission of each of the B vitamins in turn from the basal medium plus casein hydrolysate demonstrated that *S. Murraii* required thiamine, and that the presence or absence of the other vitamins had little or no effect (FIG. 2). A mixture of the two intermediates of thiamine was as effective as equimolecular amounts of the vitamin; the thiazole alone was not beneficial; pyrimidine was effective but less so than equimolecu-

[3] The vitamin mixture per ml of medium included 2.5 mμ moles of each of the following: para-aminobenzoic acid, calcium pantothenate, guanine HCl·$2H_2O$, hypoxanthine, 2-methyl-1,4 naphthohydroquinone diacetate, nicotinamide, pimelic acid, pyridoxine, riboflavin and thiamine; 2500 mμ moles i-inositol; 0.0125 μg biotin.

lar amounts of thiamine or a mixture of the two intermediates. *S. Murraii* was apparently able to synthesize thiamine from the two intermediates; it was also able to synthesize thiazole but in amounts inadequate for maximum growth; it was not able to synthesize pyrimidine.

We concluded that *S. Murraii* required thiamine (or its intermediates) and that asparagine was a less satisfactory source of nitrogen than casein hydrolysate. The addition of malt extract or coconut milk to our basal medium was beneficial, at least in part, because those natural materials supplied thiamine or its equivalent and better sources of

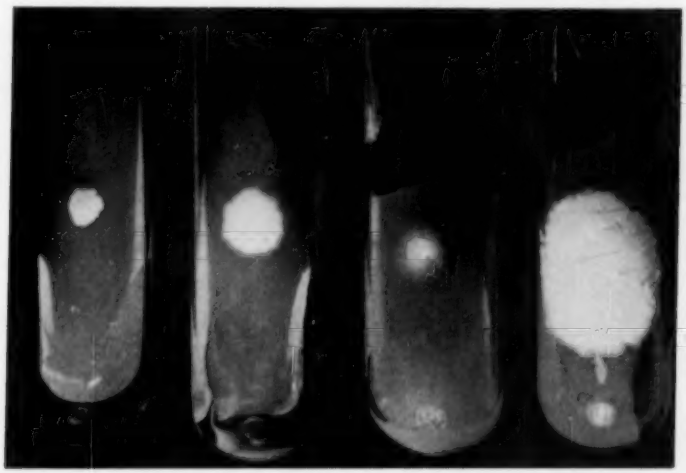


FIG. 2. Effect of thiamine on growth of *Stereum Murraii*.
Left to right. Basal agar medium; plus 20 mμ moles thiamine per tube; plus 20 mg casein hydrolysate per tube; plus thiamine and casein hydrolysate. Cultures 35 days old.

nitrogen than asparagine. However, the growth of the fungus on the basal medium supplemented with thiamine and casein hydrolysate was further increased by the addition of wood or extracts of wood.

BENEFIT FROM WOOD

Growth of the fungus on 2.5 inch blocks of beech (*Fagus sylvatica*) or birch (*Betula lenta*), set in the basal liquid medium supplemented with thiamine and casein hydrolysate, was considerably greater than that on the same medium solidified with agar. Birch shavings added to the agar medium had much the same effect, indicating that the benefit

was caused by materials extracted from the wood. A hydrolysate of birchwood markedly improved growth. Birchwood shavings were hydrolyzed by autoclaving with 4N H_2SO_4. The acid was neutralized with excess $Ba(OH)_2$, and the barium removed by CO_2. The addition of 0.12 mg of the wood hydrolysate to 25 ml of the basal agar medium

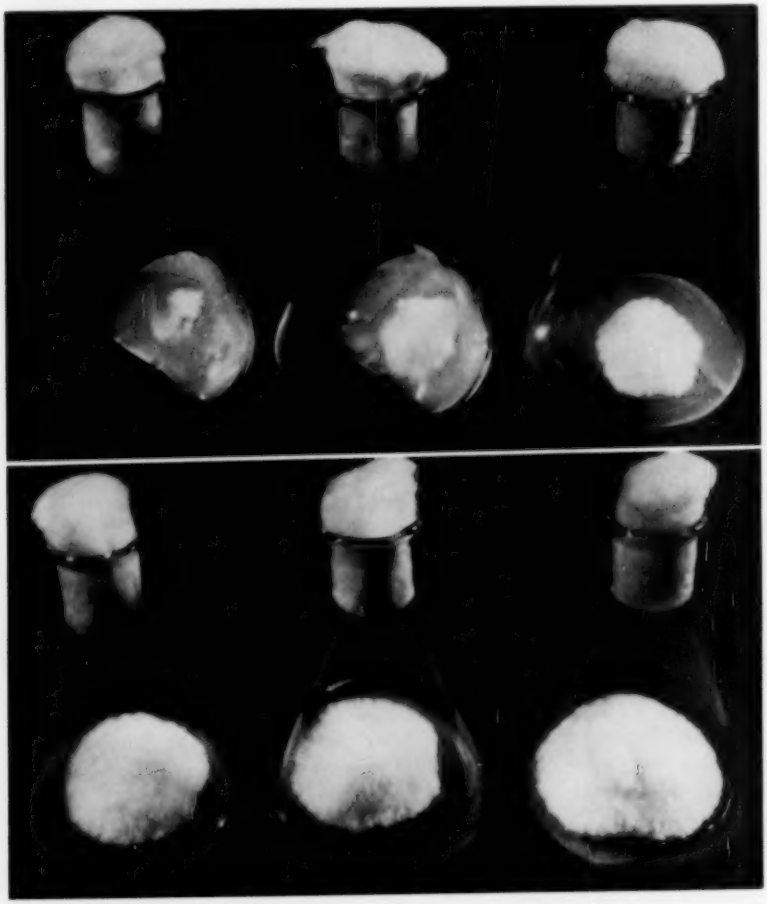


FIG. 3. Effect of wood hydrolysate on growth of *Stereum Murrayi*.

Left to right. Above. Basal asparagine medium with thiamine and casein hydrolysate; same plus 0.12 mg birch wood hydrolysate; plus 1.2 mg wood hydrolysate.

Below. Plus 12 mg wood hydrolysate; 24 mg; 48 mg. Cultures 18 days old.

supplemented with 20 mg of casein hydrolysate and 20 mμ moles of thiamine per flask improved growth slightly. The addition of larger amounts of the wood hydrolysate resulted in greater growth, and the effect of 48 mg was very marked (FIG. 3). The active material was obtained also by autoclaving 10 g of beech wood shavings in 500 ml distilled water at 15 lbs pressure for 20 minutes. The extract was filtered and concentrated to 100 ml. Growth was improved by the addition of this extract to the basal agar and to the basal liquid medium containing casein hydrolysate and thiamine. The active material was adsorbed on Norit A and eluted by ammoniacal acetone.

The wood extract contained thiamine or its equivalent and available nitrogen. This was demonstrated by suitable experiments with media lacking thiamine or nitrogen. However, growth in the basal medium supplemented with small amounts of wood extract was limited by the

TABLE I

EFFECT OF WATER EXTRACT OF BEECH WOOD ON GROWTH OF S. MURRAII

Nitrogen addition to 25 ml medium	No wood extr. Dry wt. mycelium mg.	Final pH	10 mg wood extr. per 25 ml. Dry wt. mycelium mg.	Final pH
None	2.4	5.4	12.0	5.2
20 mg cas. hydrol.	19.9	4.7	47.1	5.0
16 mg asparagine	6.1	5.7	31.2	6.0
1 mg NH_4NO_3	10.4	5.3	15.9	5.0
8.6 mg NH_4NO_3	9.7	3.7	23.5	3.2
17.2 mg NH_4NO_3	8.1	3.6	20.3	3.1

Different sources of nitrogen and 20 mμ moles thiamine per flask added to basal medium no. 1 with no asparagine. Average of triplicate cultures grown 30 days.

thiamine or available nitrogen supplied by the extract. The addition of thiamine and casein hydrolysate to the basal medium permitted the beneficial effects of the smaller amounts of wood extract to become evident.

NITROGEN SOURCES

In both agar and liquid media NH_4NO_3 was superior to asparagine as a nitrogen source, and casein hydrolysate was better than NH_4NO_3 (TABLE I). The increase in acidity as the fungus grew in the NH_4NO_3 solution may account for the superiority of casein hydrolysate. Judging from growth on agar media, 10 mg of casein hydrolysate per 25 ml of medium was somewhat better than 20 or 25 mg. Glutamic acid was somewhat better than casein hydrolysate; 15 mg was superior to 30 or

37.5 mg. Wood extract at 10 mg per 25 ml of medium was beneficial in the presence of casein hydrolysate, asparagine or NH_4NO_3 (TABLE I).

HYDROGEN-ION CONCENTRATION

The basal medium containing 10 mμ moles of thiamine and 75 mg of coconut milk solids per 25 ml was adjusted by the addition of 0.1 M potassium phosphate to hydrogen ion concentrations ranging from pH 4.1 to 6.4. After three weeks growth subcultures were made from the first set into similar solutions. Dry weights were determined for the

TABLE II

EFFECT OF WOOD EXTRACT ON GROWTH OF S. MURRAII IN BASAL MEDIUM NO. 2 WITH CASEIN HYDROLYSATE OR GLUTAMIC ACID AS SOURCES OF NITROGEN

Wood extr. added mg per 25 ml	Casein hydrol. mg per 25 ml	Initial pH	Final pH	Dry wt. mycelium mg	Glutamic acid mg per ml	Initial pH	Final pH	Dry wt. mycelium mg
none	50	4.4	4.8	6.3	50	5.4	6.1	10.4
none	25	5.4	4.9	6.5	25	5.4	6.4	13.6
none	12.5	5.2	5.3	6.8	12.5	5.5	—	12.7
0.063	12.5	5.2	5.5	8.0	12.5	—	6.4	17.3
0.314	12.5	—	5.4	9.6	12.5	—	6.3	15.4
1.57	12.5	—	5.4	13.2	12.5	—	6.2	20.8
3.14	12.5	6.0	6.2	12.8	12.5	—	6.2	20.5
7.85	12.5	6.1	6.1	12.5	12.5	4.8	6.5	19.9

Note superiority of glutamic acid as compared to casein hydrolysate and beneficial effect of 0.063 mg of wood extract per flask (25 ml medium). Average triplicate cultures grown 27 days.

original and the subcultures. The growth was somewhat better in cultures of pH 5.3 and 6.1. We concluded that the benefit of wood extract was not caused by its effect on pH.

WOOD EXTRACT AND A MORE COMPLETE BASAL MEDIUM

A medium [4] supplemented with a wide variety of growth substances was prepared. 5 g of beechwood sawdust were shaken with 250 ml of distilled water for eight hours, filtered, washed and evaporated to

[4] Basal medium no. 2 contained the mineral salts of medium no. 1 with per liter 20 g dextrose and 0.5 g casein hydrolysate or glutamic acid plus per ml 1 mμ mole of thiamine, riboflavin, pyridoxine, nicotinamide, calcium pantothenate and para-aminobenzoic acid, 0.01 μg biotine and vitamin B_{12}, 1 μg folic acid, 20 mμ moles adenine, cytosine, guanine, hypoxanthine, thymine and uracil, 0.4 mμ mole xanthine, 4 mμ moles orotic acid, 40.0 mμ moles of choline chloride and 1000 mμ moles i-inositol.

100 ml. The dry weight of the final extract was 1.57 mg per ml. The fungus was grown four weeks in 25 ml quantities of medium with casein hydrolysate or glutamic acid as sources of nitrogen and various quantities of wood extract (TABLE II). The addition of 0.063 mg of wood extract per flask increased growth in media with casein hydrolysate or glutamic acid, but greater growth was obtained with glutamic acid than with casein hydrolysate.

DISCUSSION

We assume our results to indicate that in addition to a thiamine requirement, *S. Murraii* has a partial deficiency for an unidentified growth factor(s) present in natural materials, including wood. This assumption is made because of the favorable effect on growth of the addition of 2.5 μg of wood extract per ml to a medium supplemented with a variety of growth substances and an adequate amount of available carbon and nitrogen. The hypothetical substance is water soluble, thermostable, resistant to autoclaving with 4N H_2SO_4, not destroyed by heating in alkaline solution, adsorbed on charcoal and eluted with ammoniacal acetone and not precipitated by $Ba(OH)_2$. The validity of assuming an unidentified growth factor for *S. Murraii* will depend upon the concentration and isolation of the active material.

Melin (**1954**) has reported an unidentified factor present in roots which favorably affects the growth of a number of Basidiomycetes. We have not determined whether the factor with which we are concerned is the same as that reported by Melin. It may be identical with the malt factor (Robbins, **1950**; Yusef, **1953**). Basu (**1945**) reported stimulation of a number of fungi by the water-soluble fraction of jute fiber and believed the effect was caused by growth substances of vitamin nature.

Investigation of the factors important for the growth of *S. Murraii* is complicated by the fact that some natural substances (peptone, for example) contain inhibitory compounds as well as unidentified beneficial substances. This makes concentration and isolation more difficult. Furthermore, the deficiency is partial, not complete, and the growth of the fungus is slow at best. We propose, however, to continue the investigation, especially of the material extracted from wood.

SUMMARY

Stereum Murraii is heterotrophic for thiamine. The pyrimidine portion of the vitamin molecule substitutes in part for thiamine. Glutamic

acid is a better source of nitrogen than NH_4NO_3, asparagine or casein hydrolysate. Evidence is presented for a water-soluble thermostable growth factor present in natural materials including wood.

NEW YORK BOTANICAL GARDEN
AND
DEPARTMENT OF BOTANY,
COLUMBIA UNIVERSITY

REFERENCES

Basu, S. N. 1949. Effect of water-soluble matter in jute on the microbiological deterioration of the fibre. Jour. Sci. and. Ind. Res. **8B**: 73–77.

Melin, Elias. 1954. Growth factor requirements of mycorrhizal fungi of forest trees. Svensk Bot. Tidsk. **48**: 86–94.

Robbins, William J. 1950. A survey of the growth requirements of some Basidiomycetes. Mycol. **42**: 470–476.

—— **and Roberta Ma.** 1945. Growth factors for *Trichophyton mentagrophytes*. Am. Jour. Bot. **32**: 509–523.

Yusef, Hasan M. 1953. The requirements of some Hymenomycetes for essential metabolites. Bull. Torr. Bot. Club **80**: 43–64.

THE DEVELOPMENT OF THE ASCOCARP IN PSEUDOPLEA GAEUMANNII [1]

LEWIS E. WEHMEYER

(WITH 33 FIGURES)

The fungi with which this paper is concerned belong to a group of species whose nomenclature has become greatly involved and confused. They occur as parasites on the leaves of grasses and other plants and probably exist as saprophytes upon vegetable debris. They have small ascocarps [2] with thin, light brown, parenchymatic walls and are usually sunken in the leaf tissue and have a rather well developed ostiolar beak. The asci are broad-clavate to saccate, narrowed above and with a double wall consisting of a thin outer membrane and an inner gelatinous layer which is much thickened above. The spores are oblong-ellipsoid, dictyospore, with 3–4 transverse septa, hyaline at first but brown at full maturity. Several such species have been described in the genus *Pleosphaerulina* (*P. briosiana, P. trifolii*).

The type of the genus *Pleosphaerulina, P. rosicola* Pass. is given by Berlese (**1900**) as the same as *Sphaeria intermixta* B. & Br., or *Sphaerulina intermixta* (B. & Br.) Sacc. Saccardo (**1883**), in turn, gives the type of the genus *Pringsheimia, P. rosarum* Schulz., as a synonym of his *S. intermixta*. The type of the genus *Saccothecium, S. sepincola*, also becomes involved, for Starbäck (**1891**), who seems to be the only one who has examined Fries' material of this species, states that it is the same as *Sphaerulina intermixta* (B. & Br.) Sacc. The difficulty lies in the fact that Starbäck did not describe *S. sepincola*, and one cannot be sure what Saccardo's (or Starbäck's) interpretation of *S. intermixta* was.

There were two species confused under the name *Sphaeria sepincola* by Fries (**1823**) and Fuckel (**1869, 1873**), one of which is dothideaceous and the other sphaeriaceous. Rehm (**1912**) seems to be the first to clearly separate these two species. The fungi here considered are similar to the dothideaceous fungus. According to Dr. Lennart Holm (in litt.), who has recently examined Fries' material of *S. sepin-*

[1] Papers from the Department of Botany, University of Michigan, No. *1035*.

[2] The term "perithecium" has become so denuded and controversial that its use is abandoned in this connection.

cola, it also is this dothideaceous fungus. This would make the genera *Saccothecium*, *Pringsheimia* and *Pleosphaerulina* all synonymous (according to the literature). The writer has not seen type material of either *Pringsheimia* or *Pleosphaerulina*, but collections of *Pleosphaerulina sepincola* (Fr.) Jaap (Jaap, Fung. sel. *512*, and material from the Sydow and Rehm herbaria) show a stem-inhabiting fungus with rather small (14–23 × 5–7 μ), variably septate, clavate spores, and there is some question as to whether the fungi considered in this paper are congeneric with it.

Höhnel (**1918**) came to the conclusion that they were not congeneric and erected a new genus *Pseudoplea* for the species occurring upon leaves (he claimed that they had no ostiole nor interthecial strips, which is incorrect). The genus *Pseudoplea*, therefore, can be used most safely for these species.

TABLE I

No.	Collector	Host	Locality	Spores	Asci	Ascocarps
1.	Klomparens	Agrostis	Mich.	25–30×11–12		120–150
2.	Klomparens	grass	Texas	32–34×11–12.5		100–120
3.	Klomparens	Poa	Conn.	30–35×10.5–12.5	50–55 ×30–35	100–175
4.	Jenkins	rose		26–30×10–11	85–90 ×25–36	100–130
5.	Korf	Ligustrum	N. Y.	30–32×10.5–11.5	78–89 ×35–43	40–70
6.	Simmons	Agrostis	N. H.	28.5–35×12–13	55–70 ×32–35	150–175
7.	Wolf (N.C.)	contamination	N. C.	32–37×11–12.5	70–90 ×35–45	120–150
8.	Wolf (C*2503*)	contamination	N. C.	34–37×11–12.5	80–110×27–37	

The only *Pleosphaerulina* described from a grass is *P. oryzeae* Miyake, which is given as having spores 25–32 × 9–12 μ and with 4–5 septa. The spores of the fungi here considered are always 4-septate, and run 25–37 × 11–14 μ. A fragment of what is marked as the type collection of *P. oryzeae*, in the Sydow herbarium in the Riksmuseet, yielded a *Septoria*, a *Selenophoma* and a *Leptosphaeria*, but only immature ascocarps of *P. oryzeae*. The spores in these ascocarps were 12.5–14 × 3.5–4.5 μ and 1–3-septate. These might be immature spores of the fungi here considered.

Müller (**1951**) described a new species *Pleospora Gaeumannii*, on grass stems, and reported upon the development of its ascocarp. This fungus is undoubtedly the same as the collections upon which this paper is based. The new combination **Pseudoplea Gaeumannii** is, therefore, adopted for these plants.

This group of fungi grades off into those "sclerotic" species of *Pleospora* which were originally placed in the genus *Pyrenophora*, but differ

in their smaller, thinner-walled ascocarps, without ostiolar setae, their smaller spores and more saccate asci and their much more rapid ascocarp development. *Pleospora macrospora* is somewhat intermediate between these two groups in its small non-setose ascocarps.

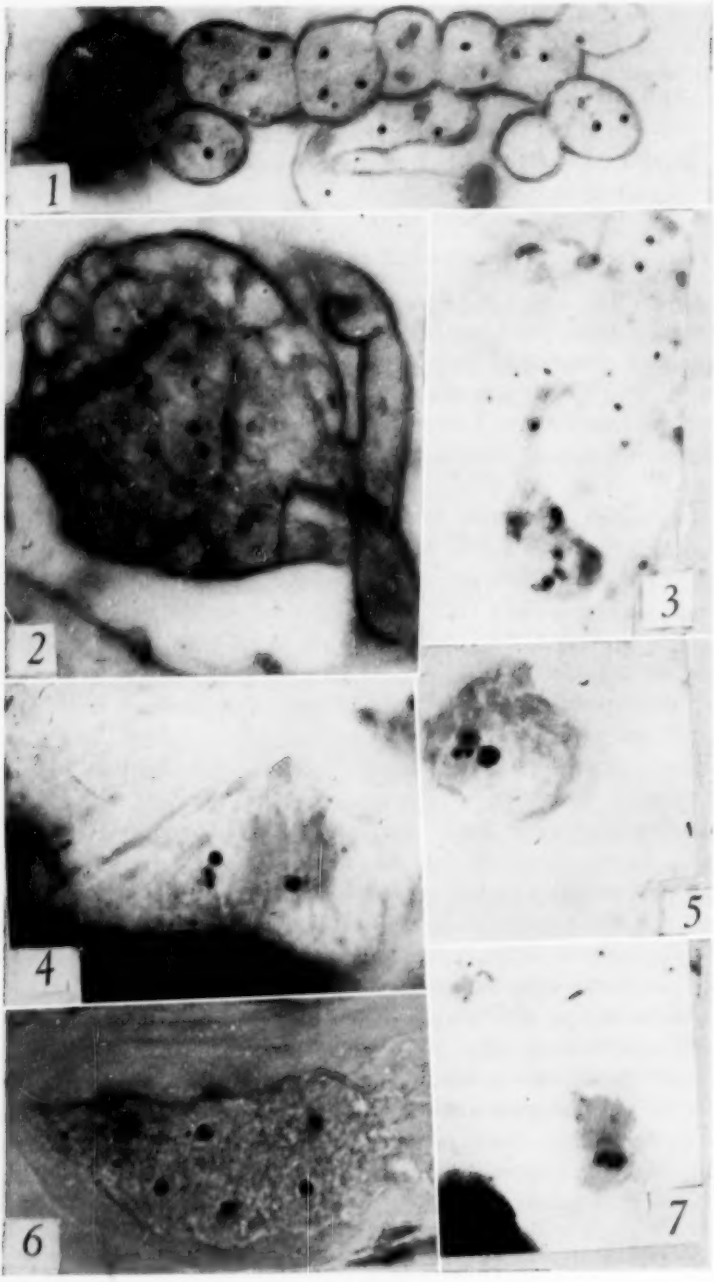
The writer has, in recent years, received eight collections of this *Pseudoplea* type, all of which are very similar, and data concerning them are given in TABLE I.

MATERIALS AND METHODS

Four (Nos. 1, 4, 7 and 8) of the above mentioned strains have been carried in culture and studied cytologically. Their developmental behavior and morphology have been strikingly similar. The only variation has been a slight one of colony color. On high sugar concentration (over 1%), strain No. 1 forms a dense black brown colony, No. 4 has a slight pinkish cast, No. 7 is red-brown and No. 8 is more olive brown in color.

Two agars were used for routine cultures: yeast agar ($MgSO_4$ 0.6 gm, KH_2PO_4 1.2 gm, maltose 2 gm, yeast extract 2 gm, H_2O 1000 cc) and Leonian's agar ($MgSO_4$ 0.625 gm, maltose 6.25 gm, malt extract 6.25 gm, H_2O 1000 cc). All four strains produced mature ascospores within 3–4 days on both agars, at room temperature. There was a striking difference in growth upon the two agars. On the yeast agar, the mycelium remained light in color, the ascocarps were lighter colored, more scattered, thinner walled and matured more rapidly. On Leonian's agar, the colonies became highly pigmented within 3–4 days, the ascocarp initials were more numerous and crowded, but the ascocarps developed more slowly, were more sclerotial and many tended to abort. It was suspected that this difference was correlated with the sugar concentration of the medium (i.e., 0.2% in the yeast agar and about 1% in Leonian's). Subsequent cultures on yeast agar, with 1% and 2% maltose added, gave darkly pigmented colonies and behavior as on Leonian's agar, supporting this view.

Blocks of agar with colonies, from both media, were fixed in Sass's (**1940**) modification (No. II) of Allen-Bouin killing fluid, 26, 67, 71, 91 and 96 hours after inoculation onto the agar, imbedded in paraffin and cut at 10 μ. The gram-iodine, crystal-violet stain was used for all routine examinations. Aceto-carmine and aceto-orcein stains were used on both smears and material fixed in Carnoy's, but no additional information was so obtained.



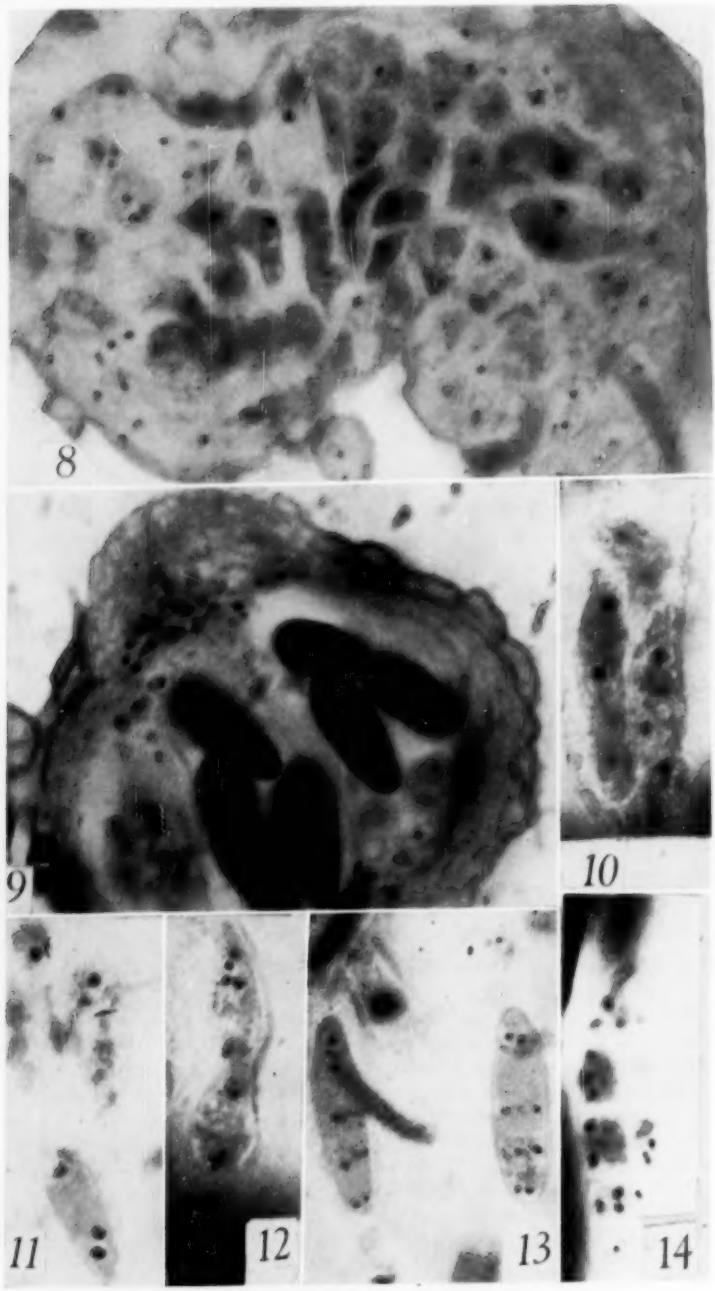
FIGS. 1–7.

RESULTS

The first thirty-six hours after inoculation there is a rapid growth of the vegetative hyphae and a rapid mitotic division of the nuclei therein. These hyphae (FIG. 15) are 3.5–5.5 μ in diameter and the cells are multinucleate. The vegetative nuclei are 0.5–0.9 μ in diameter and consist of a fine network carrying 4–5 dark-staining granules which take a distinct crystal violet and also a faint but distinct stain with the Feulgen technique. Although dividing rapidly and often lying in pairs or in groups of four or six, the division stages of these nuclei are difficult to interpret. The larger nuclei with the more distinct granules are probably in the resting or prophase. Other figures in which one or two clusters or masses of granules can be seen are most likely later phases of mitoses, but the granules are too small and commonly too crowded to distinguish or interpret.

At about thirty-six hours after inoculation the stromatal or ascocarp primordia begin to appear. At this time many of the hyphae increase in diameter (up to 8–12 μ), become septate into shorter cells with a smaller number of nuclei, show a thickening and pigmentation of their walls and tend to become swollen just below the septa (FIGS. 1, 16). Such hyphae may form short side branches which coil irregularly about the main branch, but there is no indication of any differentiation of gametic branches or transfer of nuclei at this stage. The cell or cells of such a clump of hyphae give rise to the ascocarp stroma in the following manner. The protoplasts of the larger, more active cells divide by cleavage into a number of endogenous protoplasts (FIG. 17). This is accompanied by nuclear division, but at this stage cell division has caught up with nuclear division, resulting in cells with one or two nuclei. These protoplasts may continue to divide, become lobed or form short branches, or continue cleavage to form new cells. Such growth causes the increase in size of the stroma. In this species, as previously reported for *Pleospora trichostoma* (Wehmeyer, **1954**), the writer believes

FIGS. 1–7. *Pseudoplea gaeumannii*. 1. Longitudinal view of an ascocarp initial, showing 1- or 2-nucleate condition of the cleaved protoplasts. 2. Cross-section of a somewhat later stage of an ascocarp primordium, showing a binucleate cell with enlarging nuclei. 3. Multinucleate "ascogonial" cell in the ascocarp primordium, with two division figures (slightly out of focus). 4. 4-nucleate ascus (shown also in Fig. 24) with two nuclei in focus and showing chromatin granules in the nuclear vacuole. 5. Stage of meiosis of the fusion nucleus (shown also in Fig. 23) with extranucleolar granules, two of which are larger and more distinct than the rest. 6. 8-nucleate ascus with early spore primordia, as shown also in Fig. 26. 7. Metaphase I of meiosis of fusion nucleus, as shown also in Fig. 21.



FIGS. 8–14.

that all cells resulting from this original cleavage are potentially alike and equal. Very soon, however, certain favored cells attain some physiologic advantage and two types of development, a progressive and a retrogressive one, can be distinguished.

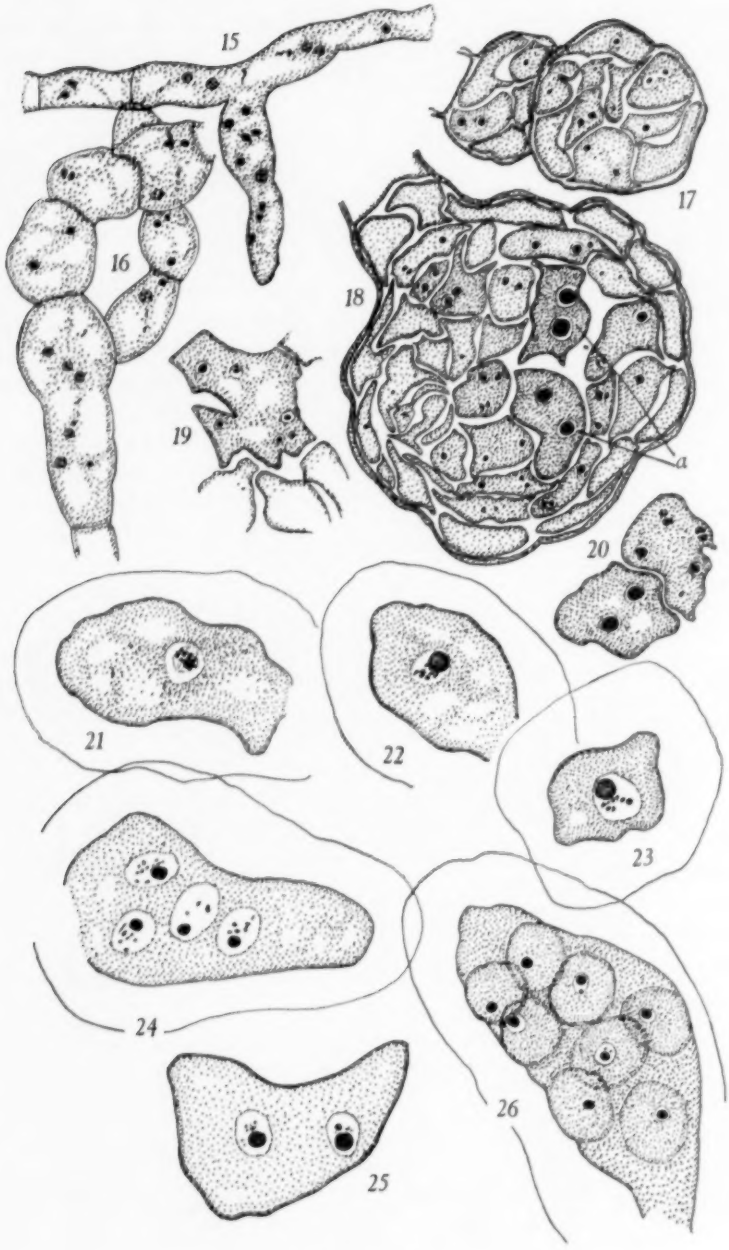
Those cells which attain some advantage and follow the progressive development, increase in size, have a more deeply staining protoplasm, continue to show nuclear division and increase in nuclear size, and retain a thin hyaline membrane. Those cells which show a retrogressive tendency enlarge no farther, form a thickened, finally pigmented wall, discontinue nuclear division, show a lighter staining, vacuolate protoplasm and finally become dead structural elements. A cell may lose its progressive advantage at any point, but those which continue this type of development become the ascogenous tissue, whereas the remaining cells form the structural walls, interthecial tissue, etc.

On agars with a higher sugar concentration (1% or more) this formation of large, pigmented hyphae proceeds more rapidly and an almost continuous layer of dark colored thick walled hyphae is formed, within which numerous ascocarp primordia arise. The retrogressive tendency is more dominant here, however, and a more sclerotial ascocarp results, and many of the primordia fail to mature. The converse is true on lower sugar concentrations.

The nuclei in the favored cells appear as more densely staining single granules which continue to increase in size and become the so-called "nucleoli" of the "sexual" nuclei. It appears as though the chromatin has contracted into a single granule, but from this point on these "nucleoli" fail to take the Feulgen stain.

There soon appear, in the centrum of the ascocarp, certain favored cells which are larger, irregularly shaped and multinucleate (FIGS. 3, 19, 20). These are what have commonly been reported as ascogonial cells. Nuclei are commonly seen in such cells in pairs, but these paired nuclei appear to be the daughter cells of division stages rather than gametic pairs. They usually show the granular character and irregular outline of dividing nuclei. Furthermore, there may be several nuclear

FIGS. 8–14. *Pseudoplea gacumannii*. 8. Centrum of young ascocarp primordium, showing cleavage of protoplasts and multiplication and enlargement of nuclei. The favored central cells take a darker stain and have larger nuclei. 9. Cross-section of mature perithecium, showing the meristematic base of the ostiolar beak which has ruptured the outer cell wall layer. 10. Spore primordia in the binucleate condition. 11. Spores with two nuclei in each of two cells. 12. Spores with four nuclei in each of two cells (one in focus). 13. Spores with four nuclei in each of four cells. 14. Mature 5-celled spore with numerous nuclei in each cell. Most of these nuclei are in division stages.



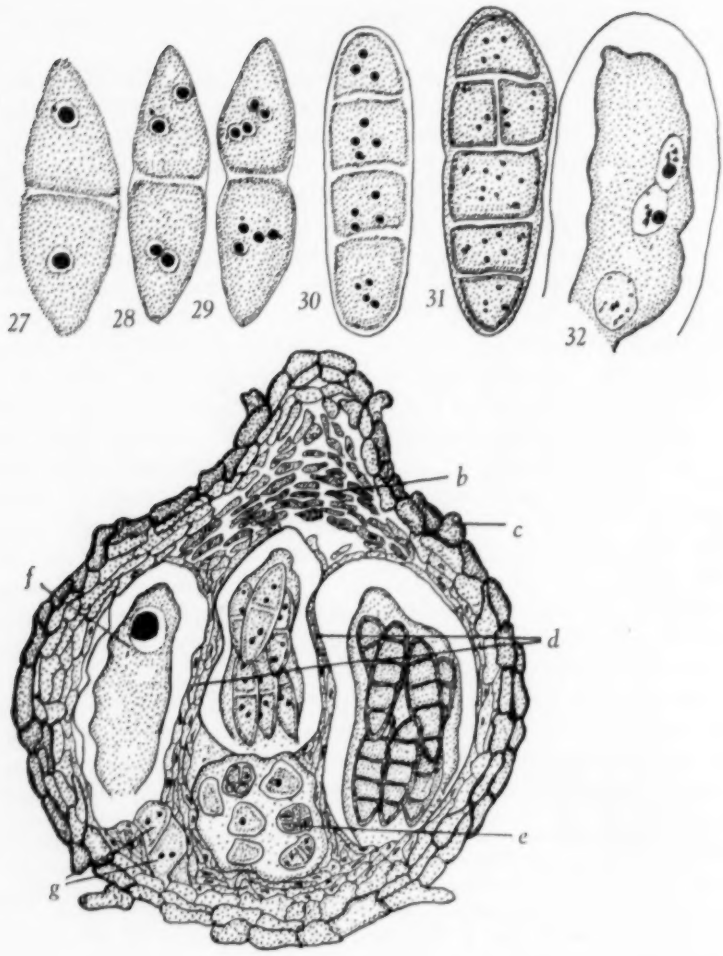
FIGS. 15–26.

pairs of various sizes (FIGS. 3, 19) and no evidence of conjugate division was ever seen.

It is very difficult in these young primordia to follow the outlines or meanderings of the individual protoplasts (FIGS. 8, 17, 18) inasmuch as they twist about one another and have very indefinite membranes. The outer cleavage furrows are likely to run parallel to the original cell wall and the outer rows of the primordial cells often show a concentric arrangement about a few larger, central angular cells. If one is intent upon finding figures commonly referred to as ascogonia and antheridia, at this time, they probably could be found, but it is the writer's opinion that the favored cells merely enlarge directly and that there is no differentiation of gametangial cells (i.e., ascogonia and antheridia) nor any nuclear pairing or fusion at this time. It is impossible of course to prove that there is no cell or nuclear fusion, but none was indicated and it seems that these large "ascogonial" cells merely serve as a reservoir in which nutrient materials are accumulated and in which nuclei may become associated and multiply. Such figures as those of Müller (**1951**, fig. 3), indicating antheridia, ascogonia and trichogyne, appeal to the writer as wishful thinking stemming from the hypothetical origin of the ascomycetes from the red algae. That some sort of nuclear association does eventually take place, however, is indicated by the eventual isolation and enlargement of a single pair of nuclei in certain of these favored cells (FIGS. 2, 18, 20).

The nuclei in these favored binucleate cells increase in size until the nucleoli are 1–1.2 μ in diameter, and lie within a small vacuole. These cells with paired nuclei develop directly into the young ascus. No cases of actual fusion of these nuclei or their nucleoli was seen, but shortly

FIGS. 15–26. *Pseudoplea gaeumannii*. 15. Vegetative hypha in active growing condition. Multinucleate with rapid nuclear division. 16. Early stage in the swelling and constriction of cells which give rise to the ascocarp initial. 17. A slightly later stage, illustrating the cleavage of the protoplasts of the cells in such an ascocarp initial. 18. Later stage of an ascocarp initial, illustrating the differentiation of the inactive outer wall layer of cells, the multiplication and enlargement of nuclei and the origin of the binucleate cells (a) with enlarged nuclei. 19. Multinucleate protoplast from a young ascocarp centrum in which the nuclei are still dividing and have not yet paired. 20. Multinucleate "ascogonial cell," as in Fig. 19, and a cell in which a single pair of enlarged nuclei has become isolated, and which will develop directly into a young ascus. 21. Sketch of nucleus shown in Fig. 7, the only metaphase I of meiosis seen. The nucleolus is shrunken and pale, but still present. 22, 23. Fusion nuclei showing extra-nucleolar chromatin granules, during meiosis. 24. Four-nucleate ascus, apparently with all four nuclei in division stages with chromatin granules (cp. FIG. 4). 25. Binucleate ascus with nuclei in the second meiotic division. 26. Eight-nucleate ascus with spore primordia just being delimited.



FIGS. 27–33.

FIGS. 27–33. *Pseudoplea gacumannii*. 27. Spore primordium in the binucleate stage. 28. Two-celled spore with four nuclei. 29. Two-celled spore with eight nuclei. 30. Four-celled spore with four nuclei in each cell. 31. Mature spore with five cells and numerous small nuclei in each cell. 32. Ascus with nuclei in the second meiotic division. One nucleus has completed division, the other (probably sliced in half) is still in the process of division. 33. Cross-section of a mature ascocarp. (b) meristematic region of cells giving rise to the ostiolar beak. (c) outer pigmented wall layer, which is ruptured by the beak. (d) interthecial tissue

after these binucleate cells appear, young asci, with a single nucleus having nucleoli 1.5–2.2 μ in diameter, are seen. It seems obvious that these young asci arise by the fusion of the two nuclei of the binucleate cells. When first seen these binucleate cells are scattered in a haphazard manner throughout the center of the ascocarp primordium. They are occasionally seen in short chains of 2–3, and sometimes appear in older ascocarps at the base of a maturing ascus, which suggest that they may divide to form short chains, but no distinct basal layer, as described by Müller (**1951**) was ever seen. Many of these binucleate cells discontinue their progressive development and remain with small nuclei or disintegrate.

Those binucleate cells which develop into asci, enlarge rapidly and take on a clavate form. The nucleus, after fusion, also enlarges, the nucleolus becoming 2.5–3 μ in diameter and the nuclear vacuole 5–6 μ in diameter. At about the time of nuclear fusion in the ascus there occurs a polarization of the ascocarp. At one side of the ascocarp there appears a meristematic area of dividing cells (FIGS. 9, 33b) just within the outer layers of wall cells. These meristematic cells show a greater affinity for stains, and divide rapidly to form a conic to cylindric mass of cells which rupture the overlying wall cells and form a small ostiolar beak. Meanwhile, the enlarging asci all elongate more or less parallel to one another and oriented toward this meristematic area. As a result further enlargement of the originally more or less globose ascocarp stroma all occurs toward one side and it becomes pyriform with a short beak. This orientation is not always upright on the surface of the agar, but is just as often variously placed horizontally with the asci parallel to the agar surface or actually with the beak directed into the agar.

The meiotic divisions must take place rapidly, for among the thousands of fusion nuclei examined only a score or so were seen in what could be interpreted as division stages. Up to the time of its greatest enlargement the fusion nucleus consists only of the homogeneous nucleolar granule (2.5–3 μ in diameter) lying within a vacuole (5–6 μ in diameter) which appears to have no membrane, or a very delicate one. This nucleolus stains strongly with crystal violet, and aceto-carmine or aceto-orcein, but not with the Feulgen stain. Only a few nuclei which could be interpreted as being in the first prophase were seen. These showed deeply staining, fine threads bearing small granules, but

of the inactive cells of the ascocarp initials which have been flattened by the developing asci. (e) cross-section of ascus and spores (showing vertical septa in both planes). (f) ascus with resting fusion nucleus. (g) binucleate cells which have failed to develop into asci.

details were difficult to make out. Most of the division stages consisted of numerous small granules variously distributed in the vacuole outside the nucleolus, but these again were too small and indistinct to count or interpret (FIGS. 5, 22, 23). Only one figure (FIG. 7, 21) which was clearly a metaphase plate was seen. There appear to be four or five pairs of granules; the nucleolus is small and indistinct, but still present. These threads and granules retained the crystal violet stain, but were not seen with the carmine, orcein, or Feulgen stain. This may be due, in part, to the fact that division stages are uncommon and fewer nuclei, stained with the latter stains, were examined. Very few binucleate asci were seen. FIG. 25 shows one such with the nuclei in the second meiotic division, again with the extra-nucleolar granules mentioned. Four-nucleate asci were more common. FIG. 4 is a photograph of such an ascus with two nuclei in focus, and FIG. 24 shows the same ascus with its full complement of nuclei, all of which show the extra-nucleolar granules of division stages. In FIG. 32, one nucleus has undergone the second meiotic division and the other is in the process of division. The absence of the nucleolus in this second nucleus is due to the fact that only a slice of the nucleus shows in this figure.

Shortly after the third division and the appearance of eight nuclei in the ascus the outlines of the protoplasts of the spore primordia appear (FIGS. 6, 26). During these three divisions and the following ones within the spore, the nucleolus becomes successively smaller, as may be seen from the figures. No nucleus, at this time, has been seen, however, without such a nucleolus. Neither has this body ever been seen to divide. The origin of the chromatic (?) threads and granules which suddenly appear at mitosis also remains unexplained. Many of the details of nuclear division, therefore, remain to be worked out.

The single nucleus of the more or less globose spore initial divides, and the spore begins to elongate and soon shows a faint cleavage furrow across its center to give a two-celled binucleate spore (FIGS. 10, 27). The nucleus in each of these cells then divides twice to give first two (FIGS. 11, 28) and then four nuclei (FIGS. 12, 29) in each cell. A succeeding mitosis is accompanied by division of each of the two cells, giving a four-celled spore with four nuclei in each cell (FIGS. 13, 30). The lower of these four cells is somewhat the longer and soon divides to form a five-celled spore (FIGS. 14, 31). About this time, either the second or third cell divides vertically, in one or two planes (FIG. 33e). Up to this point each cell has retained its complement of four nuclei, each with a distinct nucleolus. Following this stage, a number of rapid mitoses occur and in the mature spore there are a large number of

minute granular nuclei in each cell. There is a successive reduction in the size of the nucleolus in these divisions in the spore and there can often be seen one or two minute deeply staining granules in the nuclear vacuole or the adjoining protoplasm (FIGS. *26*, *29*, 30).

During this period of spore development the asci are increasing rapidly in size. Quite early in their development they show a broad gelatinous membrane which becomes much thickened at the apex. This pressure of growth crowds the remaining "retrogressive" cells of the ascocarp centrum into narrow strips between the asci. In the ascocarps on low sugar concentration agar, these show as strips of elongate nucleated cells (FIG. 33d), but on higher concentrations of sugar this retrogressive tendency of the cells of the centrum is more rapid and here the asci are often seen imbedded in a more isodiametric parenchyma. When the ascus is mature, this pressure of growth forces it through the less resistant tissue of the ostiolar beak. The ascus is a typically bitunicate one, as described by Luttrell (**1951**). The thin outer wall is ruptured near the apex, the thick inner gelatinous layer elongates into a cylindric tube carrying the ascospores with it, and then disintegrates.

DISCUSSION

As pointed out by Müller (**1951**) the type of development of this fungus is a primitive pseudosphaeriaceous one and its structure is very similar to that of *Wettsteinina*. It has been stated that one of the differential characters of the sphaeriaceous type of development is the presence of an ostiolar beak with a meristematic growing point and periphyses. This statement needs some clarification. It is well known that many pseudosphaeriaceous and dothideaceous species have well developed beaks and Müller (**1950**) has based his section *Nodulosphaeria* of *Leptosphaeria* upon the presence of periphysis-like hyphae in the ostiolar canal. Even in such a primitive type as *Pseudoplea Gaeumannii* there is a meristem which gives rise to the beak. The difference seems to be that in these stromatic types this meristem is at the base of the beak, whereas in the sphaeriaceous forms it is apical. The striking difference between the ascocarp of *Pseudoplea* and such sphaeriaceous types as the Aspergillales is that it develops entirely by a parenchymatic cell division without any filamentous hyphal complex.

SUMMARY

The ascocarps of *Pseudoplea Gaeumannii* arise by the division of a small group of enlarged cells to form a globose parenchymatic stroma.

In certain favored cells of this stroma the nuclei increase in number and size, giving rise to an ascogenous system. No cell or nuclear fusion nor nuclear pairing was seen at this stage. Eventually, enlarged cells, each with a single pair of enlarging nuclei, appear. These give rise to the asci in which nuclear fusion and meiosis occurs. The spores are at first uninucleate but at maturity contain numerous nuclei. Nuclear behavior is followed throughout. The large nucleoli are always prominent, but the details of chromatin behavior were difficult to follow, and such material often could not be detected.

LITERATURE CITED

1. **Berlese, A. N.** 1900. Icones Fungorum. Vol. 2. 216 pp. 178 plates. Patavii.
2. **Fries, E. M.** 1823. Systema Mycologicum. Vol. 2. 620 pp. Lundae.
3. **Fuckel, L.** 1869. Symbolae Mycologicae. 459 pp. Wiesbaden.
4. ——. 1873. Ibid. Appendice, II. 99 pp.
5. **Höhnel, F.** 1918. Mycologische Fragmente. Ann. Myc. **16**: 36–174.
6. **Luttrell, E. S.** 1951. Taxonomy of the Pyrenomycetes. Univ. Mo. Stud. Vol. 24. No. 3. Columbia, Mo.
7. **Müller, E.** 1951. Über die Entwickelung von *Pleospora Gaeumanni* nov. spec. Ber. d. Schweiz. bot. Ges. **61**: 165–174.
8. **Rehm, H.** 1912. Ascomycetes exs. Fasc. 51. Ann. Myc. **10**: 535–541.
9. **Saccardo, P. A.** 1883. Sylloge Fungorum. Vol. 2. Patavii.
10. **Starbäck, K.** 1890. Några mykoligiska Notiser. Bot. Notiser **1890**: 114–117.
11. **Wehmeyer, L. E.** 1954. Perithecial development in *Pleospora trichostoma* Ges. & de Not. (in press).

GAMETOGENESIS AND OOSPORE FORMATION IN SCLEROSPORA SPECIES ON SORGHUM VULGARE

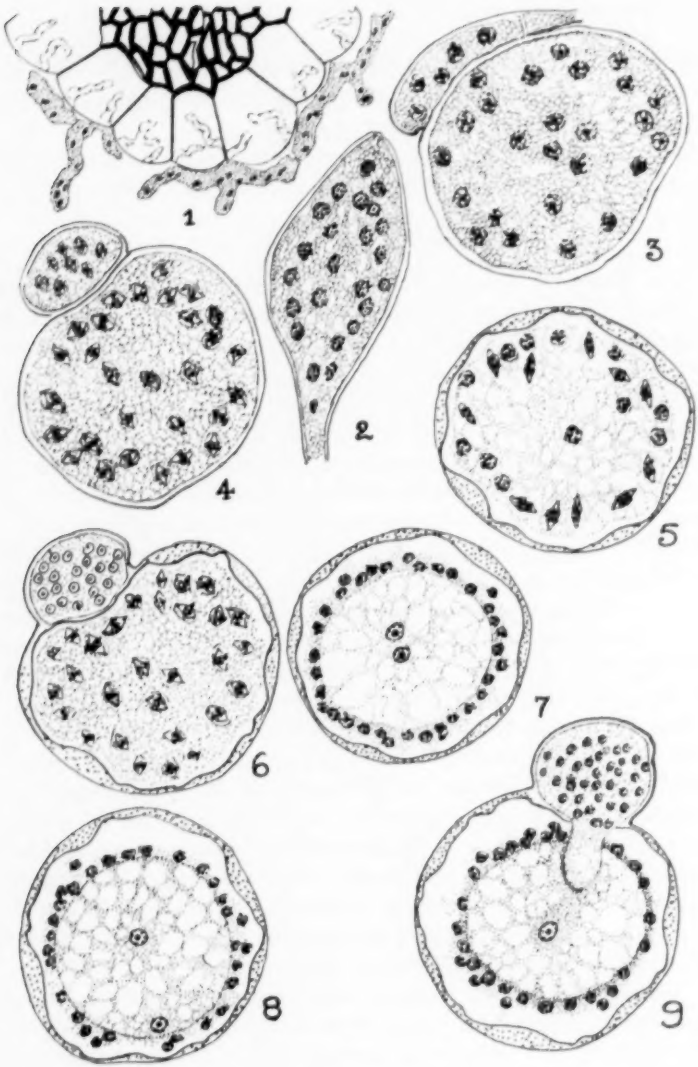
K. M. Safeeulla[1] and M. J. Thirumalachar

(with 19 figures)

The downy mildew of *Sorghum vulgare* Pers., first described by Kulkarni (2) in India under the name *Sclerospora graminicola* (Sacc.) Schroet. var. *andropogonis-sorghi* Kulk., was later raised to specific rank by Weston and Uppal (9) as *S. sorghi* (Kulk.) Weston & Uppal. In a recent paper, the authors pointed out (5) that since the epithet var. *andropogonis-sorghi* used by Kulkarni had priority, the correct name of the fungus was *S. andropogonis-sorghi* (Kulk.) Kulk. This fungus was shown by the investigations of Kulkarni, Uppal and Weston to differ morphologically and biologically from *Sclerospora graminicola* (Sacc.) Schroet. The type of branching of the conidiophores and method of germination of the conidia in the two species were observed to be different. Failure of conidia or oospores from *S. andropogonis-sorghi* to cross-infect *Pennisetum typhoideum* L., the chief host for *S. graminicola* in India, was considered as an additional evidence for separating the two species. No cytological details involved in the gametogenesis and oospore formation for *S. andropogonis-sorghi* are known in order to institute any comparison with *S. graminicola*. It may be pointed out that in the genus *Albugo* the cytological details in gametogenesis and oospore formation have offered a very reliable means of confirming species differentiation. In the present study gametogenesis and oospore formation in *S. andropogonis-sorghi* were investigated and opportunity was taken to make comparative studies with *S. graminicola* and *Sclerophthora macrospora* (Sacc.) Thirumalachar *et al.*, which until recently was placed under *Sclerospora* as *S. macrospora*.

Leaves of *Sorghum vulgare* affected with *S. andropogonis-sorghi* were collected in various stages of development and fixed in the following fixatives: formalin-acetic-alcohol, and Belling's modification of Navaschin's fluid, with or without pre-treatment with Carnoy's fluid. Paraffin sections 6–10 μ thick were cut and stained with Newton's

[1] The Senior author is grateful to the authorities of the National Institute of Sciences of India for award of an I.C.I. Research Fellowship during the tenure of which this work was carried out.



FIGS. 1–9. 1. Section of leaf showing xylem cells with haustorial processes, × 900. 2. Swollen end of hypha, × 900. 3. Young oogonium with antheridium, × 900. 4. Simultaneous nuclear divisions in the oogonium and antheridium, × 900. 5. The migration of all the nuclei except one towards the periphery, × 900. 6. All drawings were made with the help of a camera lucida.

Iodine-Gentian Violet, Heidenhain's Iron-Alum Haematoxylin and Fuelgen's staining reaction, with and without counterstaining.

GAMETOGENSIS

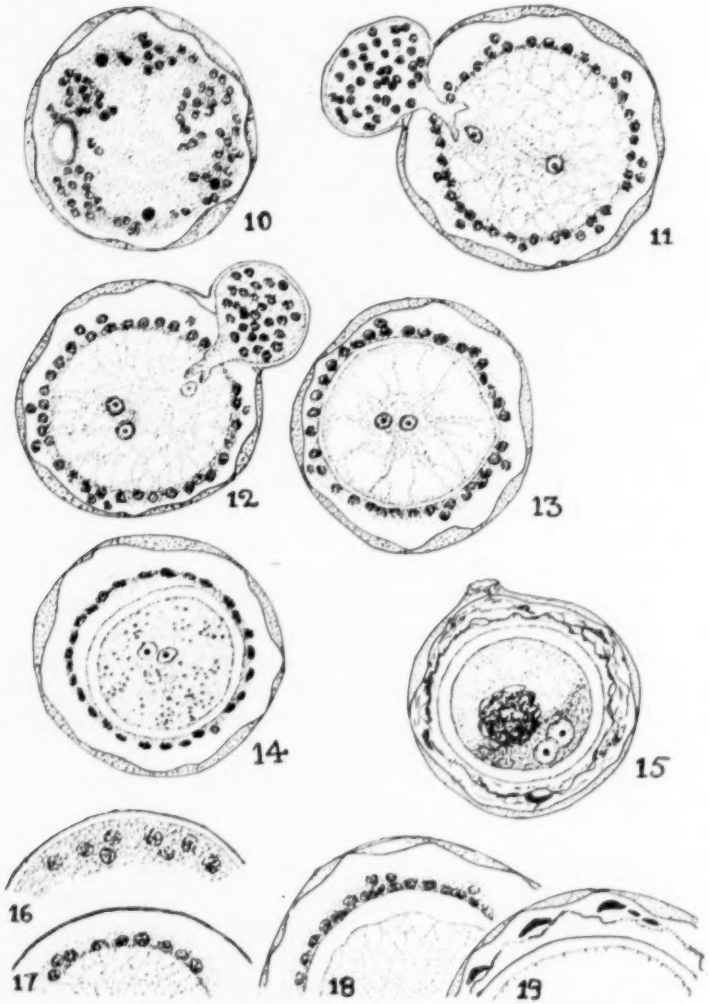
In studying the gametogenesis of *Albugo ipomoeae-panduratae* (Schw.) Swingle, Stevens (**7**) noted some points of similarities with *S. graminicola* such as in the thickening of the oogonial wall etc. Detailed account of the gametogenesis and oospore formation in *S. graminicola* was published by McDonough (**3**). He also studied gametogenesis and oospore formation in *Sclerospora macrospora* (**4**) which, as we now know, belongs to the genus *Sclerophthora*. Consequently, *S. andropogonis-sorghi* is the second species of *Sclerospora* to be investigated cytologically.

The mycelium is intercellular, developing in the mesophyll tissue between the bundles. Haustorial processes are developed into the xylem cells also (FIG. 1). After the formation of oospores, the leaf tissue between the bundles collapses, which results in the shedding of the leaves.

The initials of antheridia and oogonia are differentiated at the ends of hyphae which become swollen and filled with cytoplasmic contents (FIGS. 2, 3). After a sufficient number of nuclei has entered, a cross wall is formed which demarcates the oogonium or antheridium from the rest of the hyphae. The oogonium becomes rounded and thin-walled and contains 40 to 60 nuclei. Within the cytoplasm the nuclei are uniformly distributed. There is a single antheridium for each oogonium, which at the beginning shows 6 to 8 nuclei.

In the organization of the oosphere, there is a first simultaneous mitotic division both in the oogonium and the antheridium (FIG. 4). The divisions are intra-nuclear and there is no stage of zonation of the dividing nuclei in the oogonium. The nuclear divisions within the antheridium are completed much earlier than those of the oogonium (FIG. 6) where the dividing nuclei with their spindles persist for a long time. Even while the nuclei are still in the stage of division, all of them, except one nucleus which remains in the center, migrate towards the periphery (FIG. 5) and demarcate the region of ooplasm and periplasm. The single nucleus which remains in the center is the female pronucleus which later on gives rise to the functional female nucleus. This is in contrast to the condition seen in some species of *Albugo* where all the

Drawing to show nuclear divisions within the antheridium completed much earlier than in the oogonium, × 900. 7, 8. Female pronucleus divided and one of the daughter nuclei migrating towards the periphery, × 900. 9. Entry of antheridial tube into the ooplasm, × 900.



FIGS. 10–19. 10. Section of oosphere at region of periphery showing cavity caused by entry of antheridial tube and nuclei which have migrated to the periphery, × 900. 11. Migration of a single male nucleus from the antheridium into the ooplasm, × 900. 12. Entry of male nucleus into the ooplasm while there are two nuclei in the centre, × 900. 13, 14. Showing the male and female nuclei before fusion, × 900. 15. Oospore showing male and female nuclei before fusion, and large refractive mass of reserve food material, × 900. 16–19. Different stages in the development of oospore wall, × 1350.

Magnifications refer to figures as drawn. Reduced by 1/5 in reproduction.

dividing nuclei move towards the periphery forming a stage of zonation and one of the dividing nuclei later migrates towards the center to form the female pronucleus. In this respect *S. andropogonis-sorghi* resembles *S. graminicola* and *Scherophthora macrospora*. There is a second simultaneous nuclear division in the antheridium alone, and the mature antheridium contains 16 to 24 male nuclei. The oogonium at the time of organization of ooplasm and periplasm shows between 100 and 120 nuclei.

Before the organization of the oosphere, the female pronucleus divides and one of the daughter nuclei functions as the egg nucleus while the other one migrates towards the periphery (FIGS. 7, 8) and finally degenerates. In many cases, the non-functional daughter nucleus still remained in the center when the male nucleus had migrated into the ooplasm (FIG. 12). There is no coenocentrum in the oosphere, but the cytoplasm surrounding the egg nucleus stains deeply.

FERTILIZATION AND DEVELOPMENT OF OOSPORE

At the time when the oosphere is fully developed, the antheridial tube pushes its way into the thin wall of the oogonium and reaches the ooplasm (FIG. 9). A single male nucleus migrates from the antheridium into the ooplasm and effects fertilization (FIG. 11). In the case of *Sclerophthora macrospora,* McDonough reports the entry of several male nuclei into the oogonium even though one of them finally fuses with the egg. The male and female nuclei in *S. andropogonis-sorghi* are of the same size and shape and cannot be distinguished individually before fusion. There is no immediate fusion of the male and female nuclei and in many cases even in the oospore the two nuclei remain separate for a long time (FIGS. 13, 14, 15). The nucleoli of the male and female nuclei after syncaryon formation remain distinct for some time. The mature oospore is therefore uninucleate, and possibly, as in case of *S. graminicola,* the nuclear division in the oospore takes place just prior to germination of the oospores. The antheridium disintegrates after fertilization, and in mature oospores there are no remnants of the antheridia.

The wall of the oospore becomes differentiated soon after the migration of the male nucleus into the ooplasm. The endospore is first beneath the periplasm (FIGS. 16, 17, 18, 19). The exospore, which is not of uniform thickness, is next laid down. As the oospore enlarges, the exospore comes in contact with the oogonial wall (FIGS. 15, 19), which remains as a thin, wavy layer. In the mature oospore there is a large refractive mass of reserve food material (FIG. 15) which shows avidity with some of the stains like crystal violet.

DISCUSSION

A comparative study of the gametogenesis and oospore formation in *S. andropogonis-sorghi*, *S. graminicola* and *Sclerophthora macrospora* reveals many interesting features. *S. andropogonis-sorghi* and *S. graminicola* show very close resemblance with each other in most respects, but there are a few differences. By contrast, *Sclerophthora macrospora* shows such characteristic differences that its separation from *Sclerospora* even on the basis of gametogenesis and oospore formation alone becomes

TABLE I

COMPARISON OF SCLEROPHTHORA MACROSPORA, SCLEROSPORA GRAMINICOLA AND SCLEROSPORA ANDROPOGONIS-SORGHI

Sclerophthora macrospora (Syn. *Sclerospora macrospora*)	*Sclerospora graminicola*	*Sclerospora andropogonis-sorghi*
Sex organs terminal	Generally terminal, but rarely intercalary	Always terminal
Mature antheridium with 16 to 28 nuclei	Mature antheridium with 8 to 16 nuclei	Mature antheridium with 30 to 36 nuclei
"Receptive papilla" present	"Receptive papilla" not observed	"Receptive papilla" absent
Mature oogonium with 30 to 40 nuclei	Mature oogonium with 49 to 92 nuclei	Mature oogonium with 100 to 120 nuclei
Egg nucleus at the side near the antheridium	Egg nucleus in the centre of the ooplasm	Egg nucleus in the centre of the ooplasm
No clear demarcation between ooplasm and periplasm	No clear demarcation between ooplasm and periplasm	Clear demarcation between ooplasm and periplasm
Male and female nuclei of different sizes	Male and female nuclei of different sizes	Male and female nuclei morphologically similar
Immediate fusion of male and female nuclei	No immediate fusion of male and female nuclei	Fusion of male and female nuclei considerably delayed
Mature oospore multinucleate	Mature oospore uninucleate	Mature oospore uninucleate
Oogonial wall uniformly thick	Oogonial wall uniformly thick	Oogonial wall not uniformly thick, and with wavy margin

justified. Some of the points of difference and resemblance in the three forms are tabulated in TABLE I.

From the data presented above the following facts become manifest. While the mature oospores of *S. graminicola* and *S. andropogonis-sorghi* are uninucleate, the oospores of *Sclerophthora macrospora* are multinucleate, the fusion nucleus dividing immediately after the formation of the syncaryon. This feature is highly characteristic of species of *Albugo*. The other differences, such as the presence of receptive papilla, number of nuclei in the oogonium and antheridium, lack of clear

demarcation between ooplasm and periplasm, etc., are indicated in the table.

S. graminicola and *S. andropogonis-sorghi* show differences in the number of nuclei in the antheridia and oogonia. There is no clear demarcation between ooplasm and periplasm in *S. graminicola*, while it is a well-defined character in *S. andropogonis-sorghi*. The male and female nuclei are morphologically identical in *S. andropognis-sorghi*, while in *S. graminicola* they show slight differences in size. The persistent wall of the oogonium surrounding the oospore is of uniform thickness and smooth in *S. graminicola*, while it is of uneven thickness and wavy in outline in the case of *S. andropogonis-sorghi*. These differences warrant the recognition of *S. andropogonis-sorghi* as a separate species from *S. graminicola*. *Sclerophthora macrospora* shows characters intermediate between *Albugo* and *Sclerospora* with regard to gametogenesis and oospore formation.

SUMMARY

A detailed account of gametogenesis and oospore formation in *Sclerospora andropogonis-sorghi* is given. In many respects *S. andropogonis-sorghi* differs from *Sclerophthora macrospora*. On cytological grounds the removal of *Sclerophthora macrospora* from the genus *Sclerospora* is justifiable.

Though there are many similarities in the development of the sex organs and oospore formation between *S. andropogonis-sorghi* and *S. graminicola* there are differences which justify the removal of this species from *S. graminicola*, with which it was once merged.

Morphological and cytological studies pertaining to the development of sex organs and oospores give very useful data in classification of these fungi.

CENTRAL COLLEGE, BANGALORE
AND
MALLESWARAM, BANGALORE, INDIA

BIBLIOGRAPHY

1. **Butler, E. J.** 1907. Some diseases of cereals caused by *Sclerospora graminicola*. Mem. Dept. Agri. India. Bot. Ser. **2**: 1–24.
2. **Kulkarni, G. S.** 1913. Observations on the downy mildew (*Sclerospora graminicola* (Sacc.) Schroet.) of bajri and jowar. Mem. Dept. Agri. India. Bot. Ser. **5**: 268–273.
3. **McDonough, E. S.** 1937. The nuclear history of *Sclerospora graminicola*. Mycologia **29**: 151–173.

4. ——. 1947. A cytological study of the development of the oospore of *Sclerospora macrospora* (Sacc.). Trans. Wisconsin Acad. Sci., Arts & Letters **38**: 211–218.

5. **Safeeulla, K. M. and M. J. Thirumalachar.** 1954. Study of conidial formation and inoculation experiments with *Sclerospora* on *Sorghum vulgare* in Mysore (India). In press.

6. **Stevens, F. L.** 1896. Gametogenesis and fertilisation in *Albugo*. Bot. Gaz. **32**: 77–97; 157–169; 238–261.

7. ——. 1904. Oogenesis and fertilisation in *Albugo ipomoeapanduranae*. Bot. Gaz. **38**: 300–302.

8. **Wager, H.** 1896. On the structure and reproduction of *Cystopus candidus*. Ann. Bot. **10**: 295–342.

9. **Weston, Wm. H., Jr. and B. N. Uppal.** 1932. The basis for *Sclerospora sorghi* as a species. Phytopathology **22**: 573–586.

RESTING SPORE GERMINATION IN SYNCHYTRIUM AUSTRALE IN RELATION TO ITS CLASSIFICATION [1]

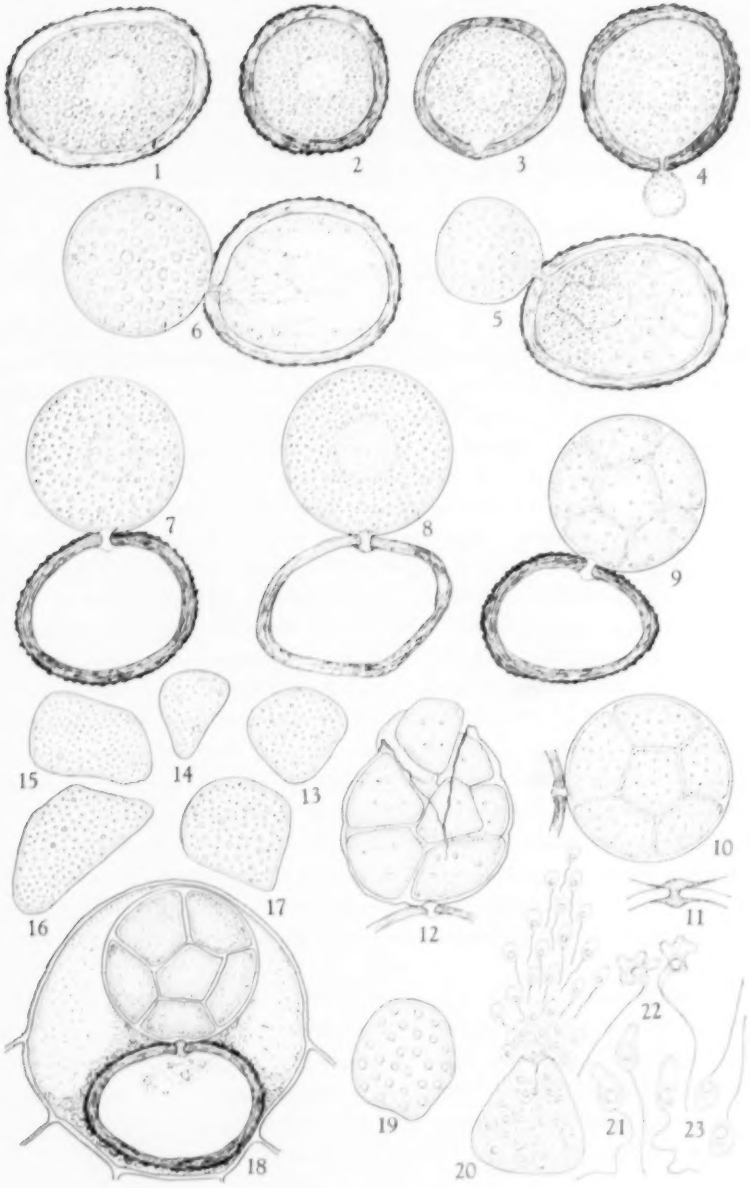
JOHN S. KARLING

(WITH 23 FIGURES)

Synchytrium includes at present more than 150 reported species, but in only sixteen of these has resting spore or zygote germination been observed. Consequently, the complete life cycles of very few species are known, and it is impossible to classify most of the *Synchytrium* species into subgenera. Species of this genus are divided conveniently into two groups on the basis of whether they are long- or short-cycled, and within these groups several subgenera have been created from time to time. In attempting to devise a rational system of classification based on developmental cycles, the author (**1953**) used the method of resting spore germination, i.e., whether it functions as a sporangium or a sorus or prosorus, as an additional criterion for distinguishing the subgenera of *Synchytrium*. According to this system long-cycle species like *S. australe, S. zygogonii, S. endobioticum,* etc., which develop prosori prior to the formation of sori and sporangia, are grouped into two subgenera, *Microsynchytrium* and *Mesochytrium,* but the final inclusion of such species in either of these groups depends on whether the resting spore functions as a sporangium or prosorus in germination. Thus, use of this key to the subgenera of *Synchytrium* involves knowledge of the complete developmental cycle of a species, and as such it emphasizes the need for more intensive study of the development of individual species, which has been lacking in most studies made during the last two decades.

Synchytrium australe (*S. modioliensis*) is a long-cycled species whose initial thallus functions as a prosorus, and from it develop the sorus and sporangia. On this basis the author (**1955b**) placed it in the subgenus *Mesochytrium*. However, a recent discovery of its germinating resting spores has shown that this classification is incorrect and that it belongs in the subgenus *Microsynchytrium* as defined by the

[1] This study has been supported by a grant from the National Science Foundation.



FIGS. 1–23.

author (**1953**). The present contribution is a description of resting spore germination in *S. australe* in relation to its classification.

The development of the resting spores in relation to the galls and their formation have already been described by the writer (**1954a**, **b**) and need not be repeated here. As noted before, the resting spores may develop in abundance in nature from late winter to early summer in Louisiana and are particularly abundant from June to August on susceptible malvaceous hosts in the greenhouses at Purdue University. The spores used in this study were collected on dried leaves of *Modiola caroliniana* and *Hibiscus esculentus* in September, 1953, and stored in envelopes until December, 1953, when germination tests were started. Very little host cell residue is present around the spores on *H. esculentus*, whereas on *M. caroliniana* the spores are enveloped usually by a thick and dense crust of residue. No germination has been observed yet among the latter spores, and the amount of residue present may possibly be an influencing factor in rate of germination. In December, 1953, leaves of *M. caroliniana* and *H. esculentus* with abundant resting spores were placed in cheese cloth bags and staked out in nature where they were subject to freezing, thawing, wetting and drying throughout the winter. Samples were brought into the laboratory at different intervals and placed in non-chlorinated tap water for observation. However, no germination was observed in this material. On April 24, 1954, dried infected leaves of these hosts which had been stored in envelopes were pulverized and placed in small Petri dishes with non-chlorinated tap water in the laboratory at room temperatures. A week later the cultures were placed in a refrigerator, 14–22° C, to prevent rapid growth of bacteria, fungi and protozoa while the author was away on a trip elsewhere. These were removed to the laboratory after a week, and within four days germination began among the spores in the *H. esculentus* material. Thus, within three weeks under such conditions germination occurred, and sporangia and zoospores were formed. Whether or not pre-treatment of spores at low temperatures initiates and accelerates germination in *S. australe* is not certain, but this seems unlikely in view of the observations noted above on resting spores kept out-of-doors during the winter. Temperature obviously influences germination, as

FIGS. 1–23. *Synchytrium australe* on *Hibiscus esculentus*. 1. Mature resting spore. 2, 3. Early stages in germination. 4–8. Stages in the development of the sorus. 9, 10. Cleavage into sporangia. 11. Plug in pore of resting spore wall. 12. Rupture of sorus. 13–17, 19. Variations in size and shape of sporangia. 18. Germination of resting spore in intact gall. 20. Dehiscence of sporangium. 21–23. Zoospores.

Curtis (**1921**), Esmarch (**1928**) and Kusano (**1930**) have shown for *S. endobioticum* and *S. fulgens*, but the optimum requirements for germination have not been determined for *S. australe*.

The mature resting spores vary considerably in size and shape (FIGS. 1–9) with a 3–5 μ thick wall. The latter is usually smooth but it may be encrusted with host residue which gives it a rough and uneven outline. It appears to be dark reddish-brown, but after germination it is distinctly light to dark amber in color which indicates that the dark-reddish hue is due largely to the content of the spore and the surrounding residue. The content is very coarsely granular or globular, and in the center is a large clear area which is the primary nucleus (FIGS. 1–4).

The first visible evidence in preparation for germination appears to be a decrease in the size of the large granules or bodies in the cytoplasm, and the material of which the refractive granules are composed becomes more dispersed. As a result the content of the spore becomes less coarsely granular in appearance (FIG. 2). The next recognizable step is the development of a small and narrow, relatively clear papilla which penetrates the wall of the spore as shown in FIG. 3. A small pore or hole, 3–4.2 μ diam., is thus formed in the wall, and within several hours the protoplasm begins to grow or flow out slowly and forms a small vesicle on the surface of the spore (FIG. 4). As the protoplasm continues to flow out the nucleus is carried along toward the pore (FIG. 5) and eventually passes out into the enlarging vesicle in the manner described by Kusano (**1930**) for *S. fulgens*. FIG. 6 shows an almost empty spore with the remnants of the protoplasm passing into the incipient sorus on the outside. The content of the latter is unusually coarsely granular, and the nucleus is not visible. At this stage the granules are yellowish-orange and usually impart a brilliant refringent color to the developing sorus. As development progresses the granules apparently break up, and their material becomes more highly dispersed, giving the protoplasm a more optically homogeneous appearance (FIGS. 7, 8).

The sori shown in FIGS. 7 and 8 are mature in size, although still uninucleate, and at this stage the sori vary from 33 to 54 μ in diameter. In general they are considerably smaller than those formed from the so-called summer prosorus. Following maturity of the sorus the pore in the wall becomes filled with a plug of hyaline material which projects slightly into the sorus as well as into the empty resting spore (FIGS. 7–12). It does not seem to be as large and conspicuous as those figured by Kusano in *S. fulgens*, and FIG. 11 shows the most extensive plug development observed so far in *S. australe*. However, the plug is diffi-

cult to see clearly in whole mounts of spores and sori, and in sectioned and stained material it might possibly be larger than shown here.

Cleavage in the sorus appears to be progressive (FIG. 9), and eventually the sporangia are delimited (FIG. 10). The number formed in a sorus varies from 4 to 14, and at maturity the sporangia are light-yellow to light-orange in color with finely granular content and a thin hyaline wall. They are predominantly polyhedral in shape (FIGS. 12–17) and vary from 18 to 36 μ in greatest diameter. As the thin, hyaline sorus wall ruptures (FIG. 12), they are liberated in the surrounding water where the sharp angular contour soon changes to a more globular shape. Within 1½ to 3 hours the minute and refractive yellowish-orange granules in the cytoplasm gradually coalesce (FIGS. 16, 17) to form the definitive refringent globules of the future zoospores (FIG. 19). Cleavage of the protoplasm soon follows, and the zoospore rudiments are delimited. With maturity the sporangium dehisces, and the zoospores slowly ooze out (FIG. 20). As in the case of the summer zoospores, they remain inactive for several seconds and then become actively motile. During this phase they are usually elongate to oblong in shape with a tapering anterior end (FIG. 21), but as they come to rest they become oval to subspherical (FIG. 23) and sometimes undergo amoeboid changes in shape (FIG. 22). In general, they are slightly smaller than those formed in the summer sporangia, and the oval ones are 2–2.5 × 3.2–3.6 μ.

In three instances germination of resting spores was observed within intact galls. One of these is shown in FIG. 18 in which the empty spore, sorus and sporangia lie in a globular unicellular gall. Its thick wall was still intact when found, and later as the sporangia dehisced and liberated zoospores, the latter swam about in the gall without escaping to the outside.

In conclusion it may be noted that the manner of resting spore germination described above for *S. australe* is similar to that reported for *S. zygogonii*, *S. longispinosus*, *S. laevis*, *S. fulgens*, *S. aureum*, *S. potentillae*, *S. mercurialis*, *S. globosum*, *S. rubrocinctum*, *S. alpinum*, *S. wurthii*, and *S. brownii*. Furthermore, it is to be noted that the development of the resting spores and their method of germination in *S. australe* are fundamentally identical with the development of its so-called summer prosorus, sorus and sporangia except for a dormant phase in the case of the resting spores. The initial summer thallus and the resting spore both function as prosori and give rise to a sorus and sporangia. Accordingly, the life cycle of this species is the same as those of members of

the subgenus *Microsynchytrium*, and for this reason it belongs in this group. *Microsynchytrium* was established by the author (**1953**) for a group of algal parasites, formerly included in the genus *Micromyces*, because their life cycles were fundamentally similar to those of *Synchytrium* species. The creation of this subgenus of *Synchytrium* was supported by the recent discovery of a terrestrial species, *S. brownii* (Karling, **1954d**), whose life cycle is identical with that of the algal parasites noted above. It is further justified by the discovery of the full life cycle of *S. australe*, which becomes the second terrestrial species to be added to *Microsynchytrium*.

In previous publications the author has described the types of galls induced by *S. australe* (**1954a**), the cytology of host reaction and gall development (**1954b**), its identity with Cook's *S. modioliensis* (**1954c**), and the development of the prosorus, sorus and sporangia (**1954d**). The present publication completes our knowledge of the life cycle of this species except for the possible presence of a sexual phase, and it is now possible to amend and complete Spegazzini's and Cook's brief diagnoses of *S. australe* as follows:

SYNCHYTRIUM AUSTRALE Spegazzini, 1881. Ann. Soc. Cient. Argentina 11: 37.

S. modioliensis Cook, 1945. Mycologia 37: 288.

Prosorus usually solitary, rarely two in a cell, subspherical, 45–95 μ, or oval, 42–60 × 58–99 μ, with a thin, light-amber wall; empty prosoral vesicle lying usually in the base of the infected cell. Sorus oval to subspherical, 44–108 μ, with a thin light-amber wall. Sporangia predominantly polyhedral, spherical, 18–42 μ, oblong, 21–32 × 38–53 μ, to slightly reniform, elongate and irregular in shape, with yellowish-orange granular content and a thin hyaline wall. Zoospores oval, 2.7–3.6 × 4.3–5.4 μ, to elongate or oblong, 2.2–2.4 × 4.6–5.6 μ, with an 0.8–1.2 μ diam. yellowish-orange refractive globule; whip-lash flagellum 16–18 μ long. Resting spores 1 to 5 in a cell, predominantly oval, 42–48 × 45–68 μ, to subspherical, 32–65 μ, with a 3 to 5 μ thick, smooth light- to dark-amber wall and coarsely granular content, usually embedded in a thick layer of residue which may fill the host cell completely; functioning as a prosorus in germination; sorus subspherical to spherical, 33–54 μ diam., cleaving into 4–14 polyhedral, 18–36 μ in greatest diam., sporangia with yellowish-orange contents and a thin hyaline wall. Zoospores oval, 2–2.5 × 3.2–3.6 μ, to elongate; flagellum, 14–16 μ long.

Sporangial and resting spore galls abundant on stems, petioles and both surfaces of the leaves, single and scattered or aggregated, some-

times confluent. Sporangial galls appearing first as mustard-yellow, then burnt-orange, and finally lavender-red in color, conspicuous, protruding, formed largely on surface of host, subspherical, 75–170 μ, oval, 72–122 × 96–160 μ, oblong, or somewhat elongate, asymmetrical with opening to infected cell usually subapical, composite and multicellular, rarely simple. Resting spore galls usually aggregated, predominantly simple and unicellular, occasionally composite and multicellular, subspherical, 45–89 μ, oval, 68–85 × 87–120 μ, oblong, somewhat dome-shaped or hemispherical with the lower part embedded in the palisade or mesophyll parenchyma, usually reddish-brown to greyish-black in color.

On *Modiola caroliniana* (*prostrata*) in Argentina (Spegazzini, **1881**), and Louisiana (Cook, **1945a**, **b**; Karling, **1954a**, **b**, **c**) and *Callirrhoe involucrata* in Kansas (Bartholomew, **1927**).

SUMMARY

The resting spore of *Synchytrium australe* functions as a prosorus in germination. In this process the content of the spore grows out to form a thin-walled, attached vesicle or incipient sorus whose protoplasm undergoes cleavage into 4 to 14 sporangia. The latter form zoospores which are fundamentally similar to those produced by the summer sporangia. On the basis of method of resting spore germination and other developmental phases *S. australe* is placed in the subgenus *Microsynchytrium*, and is the second terrestrial species to be added to this group.

DEPARTMENT OF BIOLOGICAL SCIENCES,
PURDUE UNIVERSITY,
LAFAYETTE, INDIANA

LITERATURE CITED

Cook, M. T. 1945. Species of *Synchytrium* in Louisiana. I. Description of species found in the vicinity of Baton Rouge. Mycologia **37**: 284–294.

Curtis, K. M. 1921. The life history and cytology of *Synchytrium endobioticum* (Schilb.) Perc., the cause of wart disease in the potato. Phil. Trans. Roy. Soc. London **210B**: 409–478.

Esmarch, F. 1928. Untersuchungen zur Biologie des Kartoffelkrebses. III. Angew. Bot. **10**: 280–304.

Karling, J. S. 1953. *Micromyces* and *Synchytrium*. Mycologia **45**: 276–287.

——. 1954a. The galls of *Synchytrium modioliensis*. Bull. Torrey Bot. Club **81**: 199–209.

——. 1954b. The cytology of host reaction to infection by *Synchytrium australe*. Amer. Jour. Bot. **41**: 651–663.

—— 1954c. *Synchytrium australe* Spegazzini and *Synchytrium modioliensis* Cook. Mycologia **46**: 529–533.

——. 1954d. *Synchytrium brownii*, a new species with sexual reproduction. Sydowia **8**: 27–30.

——. 1955. The cytology of prosoral, soral and sporangial development in *Synchytrium australe*. Amer. Jour. Bot. **42**: 37–41.

Spegazzini, C. 1881. Fungi Argentini, pt. 4. Ann. Soc. Cient. Argentina **11**: 1–138.

THE GENUS CIRCINELLA

C. W. Hesseltine and Dorothy I. Fennell[1]

(with 2 figures)

The genus *Circinella* was erected by van Tieghem and Le Monnier (**34**) in 1873 to include certain forms closely related to *Mucor* but differing from that genus in producing sporangiophores bearing circinate branches terminated by globose sporangia with persistent sporangial walls. These workers described three species in their new genus: *C. umbellata* with sporangia borne in umbels on circinate branches; *C. spinosa* with a sterile spine produced just below the sporangium on circinate branches from the main sporangiophore; and *C. glomerata* later recognized by van Tieghem (**32**) to be a species of *Helicostylum*. In 1872 (**33**) van Tieghem and Le Monnier had proposed, but did not characterize, the name *Circinumbella* to cover *Mucor*-like organisms with umbels of circinately borne sporangia. *Circinumbella* appears to have been based upon what is now known as *Circinella umbellata*. Since no generic description of *Circinumbella* was given and since there is no reference to any species having been placed in it, it would seem best, therefore, to treat it as a provisional name.

Schroeter (**28**) in 1886 reduced *Circinella* from the rank of genus to that of a subgenus under *Mucor*. Subsequent workers have refused to accept this classification and have continued to recognize *Circinella* as a genus.

Zygospore production by species of *Circinella* was first reported by Bainier (**1**). His account is, however, not entirely satisfactory since no measurements are given. His figures of *C. umbellata* show special zygophores branching bifidly above, with gametangia formed between two branches of the same stalk, indicating a homothallic rather than a heterothallic condition. So far as the writers are aware, no one except Bainier has indicated homothallism in *C. umbellata*. Blakeslee *et al.* (**4**) obtained zygospores of *C. umbellata* and *C. spinosa* but neither described nor illustrated the manner in which they were produced.

MEDIA

Our taxonomic descriptions of the species of *Circinella* are all based upon observations of morphology and growth habits as seen on synthetic

[1] Present address: Pioneering Research Division, QM R. & D. Center, Natick, Mass.

mucor agar (**10**) designated as SMA. The advantages of this medium for descriptive purposes are two: (1) it is a chemically defined medium and can be exactly reproduced, and (2) it allows excellent growth and sporulation for the members of this genus as well as for most Mucorales. It is hoped that, in the future, other investigators will use this medium for descriptive purposes. All cultures of *Circinella* were also studied on potato-dextrose agar (PDA) (**9**), malt extract agar (**22**), and Czapek's solution agar (**22**).

Early attempts at pairing strains of the various species of *Circinella* were made on malt extract agar. Although mature zygospores were formed on this medium between known mating types of both *C. umbellata* and *C. muscae*, it was hoped that these matings, and others yet untried, could be improved by use of a different substrate. Consequently, matings were attempted upon the following media: hay infusion agar (**22**), steep agar (**22**), SMA, PDA, and Czapek's solution agar. Of these, steep agar and PDA gave nearly equal results, with the former appearing slightly more satisfactory; lesser numbers of zygospores were produced on malt extract agar; and none were seen on SMA and hay agars.

The complete absence of zygospores on SMA, which is the medium of choice for description of the asexual stage, indicates the necessity of testing a variety of media before deciding that two strains of a species of *Circinella* are incompatible. The nature of the factor or factors present in corn steep liquor which enhance zygospore production is not known.

The zygospore descriptions given here are based upon results obtained when opposite mating types were paired upon steep agar at 25° C.

GENERIC DESCRIPTION

CIRCINELLA van Tieghem and Le Monnier, 1873. Ann. Sci. Nat., ser. V. **17**: 298.

Circinumbella van Tieghem and Le Monnier. 1872. Compt. Rend. Acad. Sci. **74**: 999 (*nomen provisiorum*).

Mycelium hyaline or colored; sporangiophores branched sympodially, indefinite in length; branches with one or many sporangia, sometimes with a sterile spine; sporangia always borne circinately at the end of branches; sporangia spherical or globose, with a persistent and incrusted sporangial wall (except in the terminal sporangia of *C. linderi*), many-spored; sporangiola never present; columellae variously shaped, always with a well-defined collar; sporangiospores usually spherical or globose, smooth; zygospores produced between equal and unadorned suspensors, nearly smooth-walled, produced upon special zygophores.

Type species: *C. umbellata* van Tieg. & Le Mon.

Numerous reports indicate that members of the genus are apparently worldwide in distribution and have been isolated from soil, dung, fermented cacao beans (**5**, **6**), musty nuts, and moldy leather goods (**16**). Hopkins *et al.* (**11**) have reported asthmatic symptoms induced in a patient by a species of *Circinella*. The genus is further mentioned in patents concerned with the production of fumaric acid (**35**) and with the oxygenation of steroids (**19**).

KEY TO THE SPECIES

1. Umbels of more than 2 sporangia present 2
1. Umbels of more than 2 sporangia never present 3
2. At least 8 or 10 sporangia in an umbel ..... *C. umbellata*
2. No more than 4 or 5 sporangia in an umbel ..... *C. minor*
3. Sporangiospores more than 10 μ in diameter ..... *C. angarensis*
3. Sporangiospores less than 10 μ in diameter 4
4. With conspicuous sterile spines on sporangium-bearing branches 5
4. Without sterile spines on sporangium-bearing branches 6
5. Sporangiophores twisted in open corkscrew turns and having many sterile spines unaccompanied by sporangia on branches ..... *C. mucoroides*
5. Sporangiophores not twisted and with spines and sporangia almost always together on the same branch ..... *C. muscae*
6. Sporangiospores always angled and irregular in shape ..... *C. simplex*
6. Sporangiospores regular in outline and shape 7
7. Sporangia extremely hard, breaking only with great difficulty; colonies dark gray, not brown in age ..... *C. rigida*
7. Not as above 8
8. With two types of sporangia, one circinately borne, the other erect, large and terminal with a subsporangial swelling; sporangiospores not globose ..... *C. linderi*
8. With all sporangia borne circinately, none with subsporangial swelling; sporangiospores globose ..... NRRL *1361*, (*C. muscae*)

1. CIRCINELLA UMBELLATA van Tieghem & Le Monnier, 1873. Ann. Sci. Nat., ser. V. **17**: 300. Pl. XXI, Figs. 18–23.

Helicostylum moreliae Berkeley & Broome, fide Cooke, 1883. Grevillea **12**: 12.

Mucor umbellatus (van Tieghem & Le Monnier) Schroeter. 1886. Cohn's Kryptogamen-Flora v. Schlesien **3**(*2*): 206.

Mucor umbellatus (van Tieghem & Le Monnier) Schroeter var. *asperior* Schroeter. 1886. Cohn's Kryptogamen-Flora v. Schlesien **3**(*2*): 206.

Circinella aspera (Schroeter) Lendner. 1908. Les Mucorinées de la Suisse 105. Fig. 38.

Circinella conica Moreau. 1913. Bull. Soc. Mycol. Fr. **29**: 339. Figs. a–f.

Colonies on SMA for 9–10 days at 26° C light grayish-olive to pale olive-buff (Ridg., **25**), most commonly with sparse aerial mycelium up to 17 mm in height but infrequent isolates showing a limited development of cobwebby white sterile mycelium, surface of agar never completely covered, sporangial colonies sometimes present; reverse olive-buff to dark olive-buff; sporangiophores to 20 μ in diam., often over 2 cm in height, branched, hyaline to brown with pigmentation especially near the

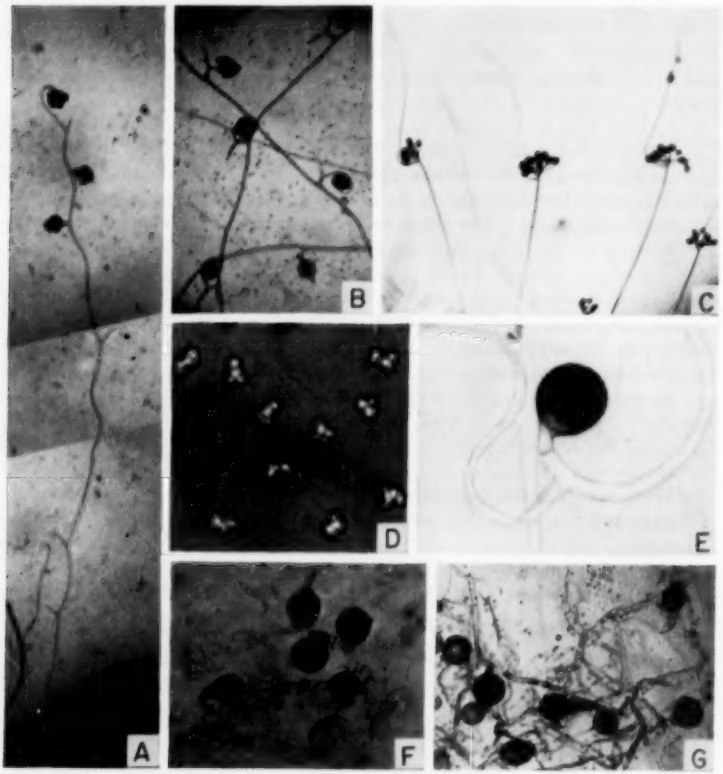


FIG. 1. A. *Circinella mucoroides*, NRRL *1354*, showing the spirally twisted sporangiophores, sterile spines, and sporangia, × 35. B. *C. muscae*, NRRL *2403*, showing sterile spines and sporangia, × 45. C. *C. umbellata*, NRRL *1713*, showing large umbels of sporangia, × 15. D. Irregularly shaped sporangiospores of *C. simplex*, NRRL *2407*, × 975. E. *C. rigida*, NRRL *2341*, single sporangium with columella visible within, × 200. F. Mature zygospores and immature fusions showing the tong-shaped suspensors of *C. umbellata*, × 60. G. Zygospores of *C. muscae*, × 85.

sporangia, roughened above; sporangia produced singly or in umbels of up to 12 on short circinate, often bi-septate stalks, these umbels (FIG. 1C) produced from successive branches along the sporangiophores and sometimes terminating the sporangiophores; sporangia black in transmitted light, frosty-gray in reflected light, spherical or dorsiventrally compressed, up to 120 μ in diam. if borne singly, up to 90 μ in diam. but mostly about 60 μ if from an umbel; sporangial wall incrusted, transparent, breaking; columellae measuring up to 84 × 90 μ but usually smaller, brownish, with a collar, irregular in size and shape, pyriform, conical or oblong, some with spines and projections, others smooth; sporangiospores 4.5–10.5 μ in diam., mostly over 6 μ, globose to almost ovoid, singly hyaline to slightly colored, walls heavy, peripheral zone hyaline, center darker; chlamydospores to 18 μ in diam., spherical or oval, near the ends of submerged mycelium; zygospores (FIG. 1F) up to 92 μ in diam., globose to ovoid, golden-brown, at first with many oil droplets which at maturity coalesce to form a single oil droplet in the center; zygospore wall appearing nearly smooth when examined at low magnifications but with definite cerebriform markings when viewed with oil immersion; suspensors up to 26 μ in diam., typically tong-shaped (FIG. 1F), occasionally straight, without coilings at their bases, smooth-walled, hyaline or faintly brown; zygophores smooth-walled bearing the zygospores just above or at the surface of the media; heterothallic.

The description is based principally upon NRRL *1713* which was isolated from horse dung at Madison, Wisconsin, in October 1942. Three other strains included in this study, and found to be typical representatives of this species, were received from Dr. A. F. Blakeslee in 1940: NRRL *1351*, received as *C. aspera*, originally from Centraalbureau voor Schimmelcultures, Baarn; and NRRL *1365* and *1366* received as *C. umbellata* isolated from rat and dog dung, respectively. Numerous additional isolates have been seen over a period of years.

Zygospores of this species were obtained for this study by mating NRRL *1351* with NRRL *1366* upon steep agar at 25° C for 8 days.

Strain NRRL *2417*, received for identification from Dr. W. B. Cooke, produced extremely low colonies never exceeding 5 mm in height on malt extract agar and showing umbels of less than 7 sporangia on SMA. The sporangiospores were slightly smaller (4.5–6.5 μ in diam.) than in other isolates of *C. umbellata*. However, its roughened columellae, its different colony appearance and the presence of as many as 8 or 9 sporangia in an umbel on PDA, indicate that it is not an isolate of *C. minor*, the only other umbellate species of *Circinella* now known. It perhaps represents a form intermediate between the two species.

Van Tieghem and Le Monnier (**34**) described *C. umbellata* at the

time they erected the genus. Schroeter (**28**) reduced *Circinella* to the status of a subgenus under *Mucor* and hence made the combination *Mucor umbellatus*.

Schroeter simultaneously erected *M. umbellatus* var. *asperior*, distinguished, according to the description, by a more vigorous growth than is typical of the species, brown sporangia, sporangiophores and sporangia punctate, and columellae adorned with numerous more or less well-developed protuberances. Lendner (**13**), not recognizing Schroeter's treatment of the genus *Circinella*, raised this variety to species rank as *C. aspera*. Zycha (**36**) treated *C. aspera* as a synonym of *C. umbellata*. NRRL *1351*, received in 1940 from A. F. Blakeslee and by him from the Centraalbureau voor Schimmelcultures in 1929 as *C. aspera*, shows no fundamental difference from typical strains of *C. umbellata*. We are, therefore, following Zycha in treating this species as a synonym of *C. umbellata*.

Berkeley and Broome (**2**) described *C. umbellata* var. *moreliae* with sporangiospores larger than those of *C. umbellata* and measuring 0.0005–0.0007 inches (12.7–17.8 μ) in diameter. Later Cooke (**7**) mentioned "*Helicostylum moreliae* Berkeley and Broome" as a synonym of *C. umbellata*. Since this name could not be found in any of Berkeley and Broome's papers, we assume that this represented an incorrect reference to *C. umbellata* var. *moreliae*.

Moreau (**18**) described *C. conica*, isolated from elephant dung in Paris, as having circinate sporangia borne in umbels. Moreau believed it differed from this species because of its small size and the branching of the sporangiophores. However, from the illustrations and measurements given, there seems to be no reason to believe that it was at all distinct from *C. umbellata*. *C. conica* (NRRL *1352*) received through Blakeslee from Baarn in 1929 proved to be *C. muscae* and quite unlike the original description given by Moreau.

2. CIRCINELLA MINOR Lendner, 1905. Bull. Herb. Boissier, ser. II, **5**: 199.

Colonies on SMA for 7 days at 24° C growing moderately, with much sterile mycelium throughout, often with sporangial colonies, pale olive-buff to cartridge-buff, in age pinkish-buff (Ridg.); reverse sometimes wrinkled, olive-buff to cartridge-buff in age; odor foul; sporangiophores arising from the substrate, reaching a height of 1.5 cm, to 25 μ in diam., roughened, light-brown, usually with a septum below the sporangium, branching irregularly with all branches circinate, typically producing umbels of 4 to 5 sporangia (infrequently up to 7 on malt

extract agar) one above the other, but with many sporangia borne singly; sterile mycelium growing out of many of the sporangiophores; sporangia globose, 40–90 μ in diam., gray to nearly black; sporangial wall translucent, incrusted, breaking; abortive sporangia present without spore formation; columellae 12–55 μ in diam., globose, oval, conical, or elongated, with walls parallel or constricted in the center, light brown, walls smooth, collar always present; sporangiospores 4.3–7.5 μ in diam., globose to short oval, smooth, hyaline, contents uniform; chlamydospores or oidia missing; zygospores not seen.

Representatives of this species grow and sporulate in a normal manner on Czapek's solution agar containing 20% sucrose and 1% yeast extract.

The species description is based upon NRRL *1353* obtained from the Blakeslee Collection in 1940 and a second culture, NRRL *2416*, obtained from the American Type Culture Collection (ATCC *9026*; Linder's Harvard strain *107*).

Zygospores could not be induced to form between these two cultures. When each was mated with *C. umbellata* NRRL *1366* (–), large numbers of suspensors were produced but less than one out of 10 of the subsequent fusions resulted in the formation of mature zygospores. Such incomplete reactions in interspecific pairings have been reported previously by Blakeslee *et al* (**4**).

C. minor was originally described by Lændner (**12**), based on strains isolated at Geneva, Switzerland, from guinea pig and rabbit dung.

C. minor is apparently very closely related to *C. umbellata* but differs in producing umbels of 5 sporangia or less, less robust sporangiophores, and more abundant sterile mycelium. In our experience, the smooth wall of the columella in *C. minor* appears to be a consistent character which we feel may be of some significance in the separation of these two species.

Reinhardt (**24**) described a veriety of *C. minor* called *asperior* with protuberances upon the surface of the columellae walls which may have represented a depauperate *C. umbellata*.

3. CIRCINELLA ANGARENSIS (Schostakowitsch) Zycha, 1935. Kryptogamenflora d. Mark Brandenburg **6a**: 98.

Mucor angarensis Schostakowitsch. 1897. Ber. Deut. Bot. Ges. **15**: 473. Figs. 5–7.

Sporangiophores decumbent, 0.5–2 cm in length, forming a low blackish mycelium, 10–20 μ thick, sympodially branched, all branches with sporangia borne circinately; sporangia globose, black, 120–200 μ

in diam.; sporangial wall black, incrusted, breaking into large pieces, leaving a large saucer-like collar; columellae large, conical or pyriform, slate-blue, with a smooth membrane, averaging 60 × 120 μ; sporangiospores fairly equal, with a double membrane, singly gray, in mass slate-blue, spherical, 10.5–14 μ in diam.; chlamydospores and zygospores unknown.

Schostakowitsch (**27**) isolated this species in east Siberia and published the above description of *Mucor angarensis* based on his studies of the organism cultured on bread. Zycha (**36**), however, recognized its true relationship and made the proper new combination, *Circinella angarensis*.

Although no culture of this species has been studied by the authors and no available material or further reports are known, we feel that the species must be recognized since it was described and figured as possessing larger sporangiospores than any other species of *Circinella*.

4. CIRCINELLA MUCOROIDES Saito, 1907. Centbl. f. Bakt. II. **17**: 159. *Circinella chinensis* Naganishi & Kojiro. 1942. Jour. Ferm. Tech. **20**: 409. Pl. 3.

Colonies on SMA for 8 days at 24–26° C covering the entire plate, at least 1.5 cm high, pale olive-gray to pale gull-gray (Ridg.), brown in age; reverse pale smoke-gray to marguerite-yellow; odor yeast-like; sporangiophores 1.5 cm high and to 18 μ in diam., arising from the substrate, rather weak, minutely granular, hyaline to light brown beneath the sporangium, characteristically twisted or in loose open spirals (FIG. 1A), terminating in 1 or 2 sporangia, branching sympodially to produce either sterile spines or circinate sporangium-bearing stalks (FIG. 1A); septations occurring where spines and stalks are separated from the sporangiophore and in the curvature of the sporangium-bearing stalks; circinate stalks bearing either a single sporangium, sporangium and a spine, or two sporangia; sporangia globose to slightly flattened, usually 50–70 μ but up to 85 μ in diam., white then dark gray, sometimes glistening or frosty-appearing; sporangial wall smooth to slightly roughened, transparent; columellae cylindrical, oval or nearly pyriform, 16–30 × 30–42 μ, some up to 50 × 70 μ; collar always present, occasionally with projections above, gray to light brown; sporangiospores globose to short oval, smooth, light gray singly, 3.5–6.5 μ in diam., a few oval ones up to 5.5 × 7.5 μ, contents uniform; zygospores and chlamydospores not seen; at one month substrate mycelium showed a few globose thin-walled cells.

This species grew readily on Czapek's solution agar with 20% sucrose and 1% yeast extract.

The above description was based upon two cultures: NRRL *1354* obtained in 1940 from the Blakeslee Collection as *C. mucoroides*, originally from Baarn in 1929, and NRRL *2415*, the type culture of *C. chinensis* Naganishi and Kojiro (No. *4453*) obtained from the Institute for Fermentation, Osaka, Japan.

When these two cultures were mated on steep agar at 25° C, no zygospores were produced.

C. mucoroides was originally described by Saito based on a culture isolated from koji.

Saito, recognizing the relationship of his *C. mucoroides* to *C. muscae* (*C. spinosa*), considered that the less markedly circinate character of the sporangium-bearing branches, the sporangiophores with terminal sporangia, and the greater diameter of the sporangiospores warranted recognition as a new species.

In our studies, the most readily identified characteristics separating this species from *C. muscae* are the spiralled sporangiophores and the sterile spines which occur unaccompanied by sporangia. The first of these two characters was neither figured nor described by Saito. It was, however, plainly illustrated by Naganishi and Kojiro for *C. chinensis*. Since NRRL *2415*, the type strain of *C. chinensis*, agrees in this and in all other details with NRRL *1354* (presumed type of *C. mucoroides*), the two are considered synonymous.

5. CIRCINELLA MUSCAE (Sorokine) Berlese & de Toni, 1888. Saccardo's Syll. Fung. **7**: 216.

Heliocostylum muscae Sorokine. 1870. Bull. Soc. Imp. Nat. Moscou **43**: 256. Pl. 4.

Circinella spinosa van Tieghem & Le Monnier. 1873. Ann. Sci. Nat., ser. V. **17**: 305. Figs. 24–49.

Mucor spinulosus (van Tieghem & Le Monnier) Schroeter. 1886. In Cohn's Kryptogamen-Flora v. Schlesien **3**(*2*): 206.

Circinella nigra Bainier. 1903. Bull. Soc. Mycol. Fr. **19**: 170. Figs. 6–9.

Circinella sydowi Lendner. 1913. Bull. Soc. Bot. Genève, ser. II. **5**: 29. Figs. 1–2.

Colonies on SMA for 8 days at 26° C usually somewhat restricted but in some isolates spreading rapidly, often surrounded by sporangial colonies, at first white, then olive-gray to deep olive-gray becoming wood brown to almost Saccardo's umber (Ridg.) at one month, variable in height from 0.5 to 1.5 cm; substrate mycelium filled with oil droplets, compact especially in sporangial colonies; reverse with wavy irregular appearance, at first white, at one month avellaneous; sporangiophores

arising from the substratum, 18 μ in diam., up to 15 mm in height, nonseptate, hyaline to brown, sympodially branched, sometimes with two main lines of branching; fertile branches circinate, bearing a single sporangium, two sporangia, or a single sporangium and a sterile spine (FIG. 1B); many shorter sporangiophores with alternate arrangement of sporangia and without spines; sterile spines light in color, cut off by a septum; branched short rhizoid-like structures formed where sporangiophores touch the surface of the medium; sporangia globose to slightly dorsiventrally flattened, typically 30–62 μ in diam., some up to 100 μ, at first white, then dark gray, becoming brown in age; sporangial wall persistent, smooth or nearly so, breaking, hyaline; columellae up to 30 × 54 μ but typically 15–20 × 20–36 μ, variable in shape, pyriform, somewhat constricted in the center, oblong or conical, hyaline to light brown, some smooth, others with protuberances or spines, much of the sporangial wall remaining attached; sporangiospores globose, sometimes short oval, variable in diam. from 3–7 μ, mostly 5–6 μ, smooth, hyaline, black in mass, contents homogeneous; zygospores (FIG. 1G) 30–65 μ in diam. formed at the agar surface, golden brown to reddish brown, globose, oil droplet in center, then a zone of cytoplasm and a heavy outside wall, wall slightly roughened in a cerebriform pattern visible at high magnifications; suspensors equal, 15–18 μ in diam., hyaline, straight, never tong-shaped, smooth, arising opposite each other from short, roughened zygophores; heterothallic.

The species description is based principally upon NRRL *2403*, isolated by the senior author from Brazil nuts, in December, 1946. Isolates of this species have been reported from soil, manure, and Brazil nuts. It is our experience that musty nuts are an excellent source for obtaining isolates of this species. Of the many strains of this species seen by the writers, many are identical with the above culture.

It has been observed that all *C. muscae* strains exhibit a characteristic color change. The colonies initially form a white aerial growth which later becomes dark gray and in age dark brown. In most isolates of *C. muscae*, the brown pigmentation of the tall sporangiophores masks the dark gray of the sporangia. In other isolates producing only a few of these tall sporangiophores, the colonies remain gray for a much longer time due to the greater relative numbers of sporangia. In our opinion, *C. nigra* described by Bainier (1) was probably based upon one of these more persistently gray strains.

In this study, zygospores of *C. muscae* were obtained by mating NRRL *1358* and NRRL *1359* on steep agar at 25° C. They differ from those of *C. umbellata* in being borne between straight rather than tong-shaped suspensors, and in their smaller diameter.

Zygospores of this species have been reported and described previously by Bainier (**1**) in his description of *C. nigra* (= *C. muscae*) and reported but not described by Blakeslee *et al.* (**4**) for *C. spinosa*.

Sorokine described and illustrated *Helicostylum muscae* (isolated from a fly—hence the name) as a brown fungus with circinately borne persistent sporangia up to 61 μ in diam., producing spines from the sporangial stalks, and with sporangiospores 5.6–2.6 μ in diam. This information, in our opinion, leaves little doubt that the name was based upon a strain of the species which has been more widely recognized as *C. spinosa*. *H. muscae* was properly transferred to the genus *Circinella* by Berlese and de Toni in 1888. Van Tieghem and Le Monnier recognized the synonymy of *H. muscae* with their species *C. spinosa* at the time their description was written. Both Fischer (**8**) and Naumov (**21**) accepted van Tieghem and Le Monnier's treatment of the two names.

Therefore, although the name *C. spinosa* has been extensively used and is far more appropriate, we feel that Berlese and de Toni's recombination of Sorokine's name must be accepted as the proper designation for this well-known and widely distributed species.

Schroeter in 1886 (**28**) transferred *C. spinosa* into the genus *Mucor* as *M. spinulosus*, placing it under his subgenus *Circinella*.

C. nigra, according to Bainier, was similar to *C. spinosa* in its microscopic aspects, but differed in producing dark gray rather than brown colonies. Considering the recognized variation in colony color among strains of *C. muscae* (see discussion above), this does not appear to us to be sufficient grounds for maintaining *C. nigra* as an independent species.

C. sydowi was described by Lendner (**14**) as a strain showing a sterile spine on only the first branch from the sporangiophore, and producing sporangia and spores somewhat larger than those of *C. muscae* (*C. spinosa*). Culture No. NRRL *1364*, obtained from Baarn through Blakeslee (presumably Lendner's type culture), proved to be a typical strain of *C. muscae* with differences in dimensions of spores and sporangia too slight to warrant continued recognition of *C. sydowi*. The species is accordingly reduced to synonymy.

Zycha's treatment of *C. sydowi* was apparently based upon a strain completely unlike the species as described and more nearly approximating *Mucor laxorhizus* Ling-Young, *q. v.* (p. 208).

NRRL *1361*, originally isolated from Paradise nuts by A. F. Blakeslee in 1919 and identified by him as *C. spinosa* (+), differs from *C. muscae* in producing lower, more rapidly spreading colonies with con-

siderable sterile mycelium, and sporangial branches completely devoid of spines but with some abortive sporangiophores terminating in sterile points. However, this strain mates freely with NRRL *1358*, here considered as a normal *C. muscae*, to produce abundant and entirely typical zygospores. We, therefore, hesitate to exclude this culture from *C. muscae* in spite of the complete absence of the characteristic sterile spines. It is treated individually in the species key to provide a means of placement for aberrant strains lacking spines but giving a typical mating reaction with known strains of *C. muscae*.

6. CIRCINELLA SIMPLEX van Tieghem, 1875. Ann. Sci. Nat., ser. VI. **1**: 92. Pl. II, Figs. 52–54.

Mucor simplex (van Tieghem) Migula. 1910. Kryptogamenflora Deutschl., Öst. u. d. Schweiz **3**(1): 194.

Colonies on SMA for 8 days at 26° C rather restricted, 4–6 mm in diam., less than 0.5 cm tall, white with more or less sunken centers and with wide moist margins in age (24 days) near dark olive-buff (Ridg.), with sporulation apparent as a definite brownish zone about the margin of colonies; reverse olive-buff to deep olive-buff, in age near deep colonial buff, zonate; sporangiophores less than 5 mm high by 18 μ in diam., arising from substrate, hyaline to faintly brown, walls roughened, branching variable, often with several secondary branches, each successive branch arising just below the sporangium in the region of the curvature, septations in arch of branches bearing sporangia and also in region of origin of branches, spines and umbels absent; sporangia to 70 μ in diam., white then brown, globose, incrusted, breaking; columellae up to 23 × 26 μ in size, oval, conical, or dorsiventrally flattened in the smaller ones, with well-defined collars, walls colorless, smooth, without projections; sporangiospores mostly 3–5.5 μ but some up to 11 μ in length, very irregular (FIG. 1D), some roughly oval and angled, others triangular or curved, smooth, contents with conspicuous oil droplets and granules; chlamydospores and zygospores not seen.

The species description is based upon NRRL *2407* received from Baarn as Zycha's strain of this species isolated from Brazilian soil. The type culture of this species, originally isolated from dog dung by van Tieghem, has long since been lost.

The above description agrees closely with van Tieghem's original account except in spore shape and dimensions. The irregularly shaped, angular spores, different from those of any other known species in the genus, were included in Zycha's description of this species and have been observed on a great variety of media at different ages. We are following Zycha (**36**) in assigning this culture to *C. simplex* and broadening the description to include these characteristically shaped spores.

Migula (**17**), following Schroeter in not recognizing the genus *Circinella*, transferred this species into the genus *Mucor*.

7. CIRCINELLA RIGIDA Smith, 1951. Trans. Brit. Mycol. Soc. **34**: 19. Figs. 7–8.

Colonies on SMA for 14 days at 24° C less than 1 cm tall, rather rapidly growing, pale neutral gray to light neutral gray, never showing any brown color even in age; reverse light olive-gray (Ridg.); odor practically none; sporangiophores from 4.5–11 μ in diam., smooth to slightly roughened, hyaline, with a septum below the sporangia, arising from the substrate, greatly twisted and limp, hence soon collapsing, bearing but a single sporangium on a branch, never umbellate; sporangia (FIG. 1E), 20–72 μ in diam., at first white then black, borne circinately, rather pyriform in shape, with basal portion of columellae brown and showing below; sporangial wall incrusted, dark, not allowing spores to be clearly seen within, extremely resistant to breaking; columellae 20–36 μ in diam., dorsiventrally compressed, with an apophysis, dark gray, with most of sporangial wall attached; sporangiospores 3.5–6 μ in diam., globose but also slightly angled as a result of mutual pressure in the sporangium, smooth and heavy-walled, light bluish black, often adhering together when squeezed from the sporangium, contents uniform; chlamydospores and oidia not seen; zygospores unknown.

The species description was based upon the type culture obtained from George Smith as his No. *BB 247*. It was originally isolated from soil by J. H. Warcup at Lakenheath Warren, Suffolk. This culture has been added to the Culture Collection as NRRL *2341*.

This species may be distinguished from other species of *Circinella* by its persistently metallic gray colonies, the strength of the sporangial wall, the sporangia borne at the end of an almost complete circle of the sporangiophore branch, and the presence of columellae with apophyses similar to those seen in *Absidia*.

8. **Circinella linderi** n. sp.

Coloniae avellaneae, irregulariter zonatae; sporangiophora bitypica; alia 1.5 cm alta, 18 μ in diam., inferne irregulariter ramosa, sporangia erecta 1–3 circinate disposita ferentia; alia brevia, minus quam 2 mm alta, sympodialiter ramosa; sporangia terminalia erecta alba dein grisea, globosa, 40–120 μ in diam., deliquescentia, columellis cylindricis 20–40 × 20–65 μ, tumore subsporangiali clavato usque ovoideo 18–40 μ in diam., praeditis; sporangia circinata globosa, 30–80 μ in diam., rumpentia, sine tumore subsporangiali, columellis globosis usque hemisphaericis, 25–30 × 17–23 μ; sporangiosporae ovales usque fere ellipticae, numquam globosae, e sporangiis omnibus in magnitudine uniformes, 6.5–13 × 5–7.5 μ; chlamydosporae zygosporaeque ignotae.

E texto culta, Florida.

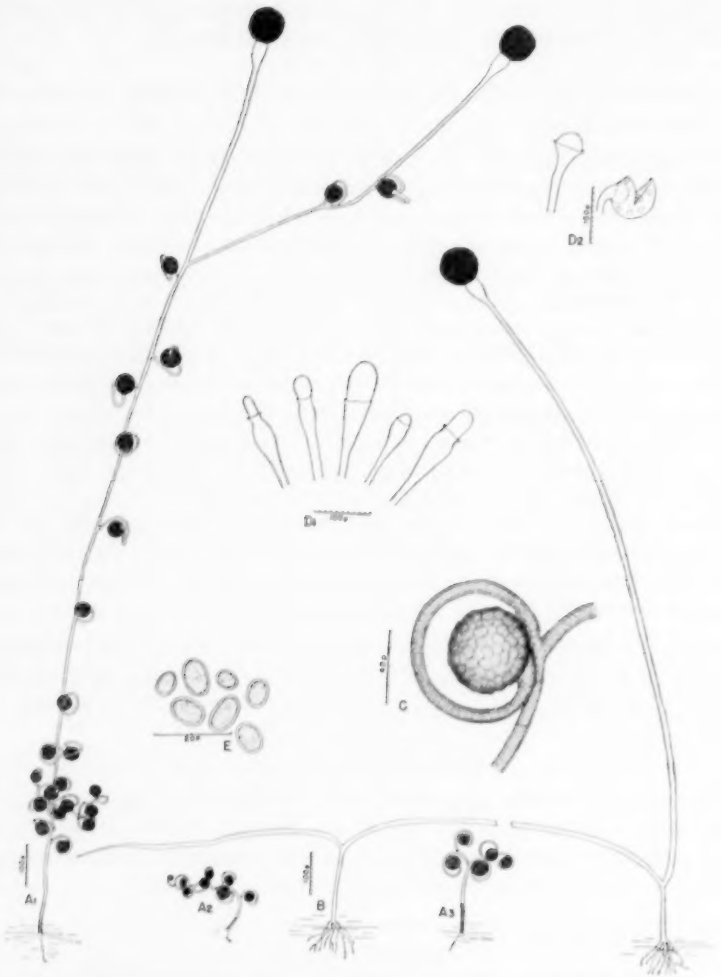


FIG. 2. *Circinella linderi* n. sp., NRRL *2342*. A. Sporangiophores at low power. (1) Tall sporangiophore showing sporangia borne circinately and upright. (*2*, 3) Short sporangiophores with circinately borne sporangia only. B. Rhizoid and stolons with erectly borne sporangium produced from the stolon. C. High magnification of a single circinately borne sporangium. D. Columellae. (1) Variation in size and shape of columellae and subsporangial swellings of large terminal sporangia. (*2*) Detailed drawing of circinately borne sporangia and their columellae. E. Sporangiospores. Camera lucida drawings.

Colonies on SMA for 15 days at 24–26° C restricted, up to 1.5 cm in height, at first white, later avellaneous; reverse white, later avellaneous, irregularly zonate; odor none; sporangiophores of two heights, all arising from the substrate; tall sporangiophores (FIG. $2A_1$) 6–18 μ in diam., terminated by one or more sporangia borne erectly, below which are short circinate branches arranged irregularly along the sporangiophore and bearing 1 to 3 sporangia; short sporangiophores (FIG. $2A_{2,3}$) less than 2 mm in height, abundantly produced, branched sympodially, bearing circinate sporangia only, roughened just above the substrate; on Czapek's solution agar branched rhizoids and stolons (FIG. 2B) bearing occasional circinate sporangia along their entire length and terminating in large sporangia; branches bearing sporangia (FIG. 2C) circinate or forming a complete circle, rigid, roughened, not septate, without spines or umbels, septations about the origin of the branch; large terminal sporangia (FIG. 2A, B) white, then olive-gray, pale yellow in reflected light, 40–120μ in diam., deliquescing, smooth-walled, fragile, globose, sporangial wall hyaline, with a definite swelling beneath it; subsporangial swelling (FIG. $2D_1$) 18–40 μ in diam., clavate to ovoid, brown in color, fading below, resembling the subsporangial swelling of *Pilobolus;* smaller circinately borne sporangia (FIG. 2C, D_2) 30–80 μ in diam., gray, globose to obovate, smooth-walled, many-spored, walls hyaline, persistent, breaking, without subsporangial swelling; columellae of terminal sporangia (FIG. $2D_1$) 20–40 × 20–65 μ; smooth or slightly indented, cylindrical and rounded above, light brown with color extending down into subsporangial swelling, collar left as a line or may be completely absent; columellae of circinate sporangia (FIG. $2D_2$) 25–30 × 17–23 μ in size, a few up to 30 × 36 μ, globose to hemispherical, brown, smooth-walled, leaving much of the sporangial wall as a collar; sporangiospores (FIG. 2E) 6.5–13 × 5–7.5 μ, oval to almost elliptical, never globose, smooth, thin-walled, of the same size for all sporangia, contents usually uniform although they may be vacuolate or finely granular, singly colorless to faintly yellow; chlamydospores and zygospores not seen; substrate mycelium in age very irregular and often with a series of swollen oval cells or enlarged portions filled with small droplets or granules; growth poor at 37° C.

The type culture, NRRL *2342,* was sent to the senior author by Dr. E. T. Reese of the Philadelphia Quartermaster Corps as *Circinella* sp. (PQMD *672*) (**23**), originally isolated from poplin in Florida. It is named in honor of the late Dr. D. H. Linder who originally isolated the organism and identified it as a species of *Circinella.*

This extremely interesting species is readily distinguished from all other species of *Circinella* by its two types of sporangia, its subsporangial swelling, and the shape of its spores. It shows some resemblance to a

number of other genera in the Mucorales. The subsporangial swelling is reminiscent of the genus *Pilobolus;* the rhizoids and stolons with fertile branches on the stolons are similar to those seen in *Absidia;* the terminal sporangia are like those of species of *Mucor;* and the small circinate sporangia with persistent walls borne on the same sporangiophore with the *Mucor*-type sporangium is suggestive of *Helicostylum* or *Thamnidium*. However, all the sporangia except the terminal one are borne circinately and since the walls of these sporangia break as is typical of all species of *Circinella*, it seems logical to place it in that genus. It may, however, represent a form intermediate between *Circinella* and *Helicostylum*.

POSITION UNCERTAIN

MUCOR LAXORHIZUS Ling-Young, 1930. Rev. Gen. Bot. **42**: 732. Fig. 30.

Ling-Young (**15**) characterized and illustrated *M. laxorhizus*, isolated from soil in 1930. This species was described as having dark colonies 2–3 mm high with sterile aerial mycelium; sporangiophores 10–30 μ in diam., with many septations; sporangia black at maturity, 60–150 μ in diam.; columellae 25–80 μ in diam.; globose sporangiospores 5–6 μ in diam.; chlamydospores present. Ling-Young's illustration showed circinately borne sporangia without sterile spines on the branches. Neither type culture nor type material is known to exist. NRRL *1361* discussed under *C. muscae* agrees rather well with Ling-Young's description except that the sporangia and columellae do not reach the magnitude described by Ling-Young, and no chlamydospores were observed in cultures growing on SMA, PDA, or Czapek's agar.

Zycha (**36**) considered this species synonymous with *C. sydowi*. However, his illustrations of *C. sydowi* show a form completely devoid of the *C. muscae* type of spines and unlike *C. sydowi* as originally described and illustrated by Lendner. Hence, although his placement of *M. laxorhizus* in the genus *Circinella* is undoubtedly correct, his treatment of this species as a synonym of *C. sydowi* (= *C. muscae*) is considered invalid.

EXCLUDED SPECIES

CIRCINELLA TENELLA (Ling-Young) Zycha, 1935. Kryptogamenflora Mark Brandenburg **6a**: 99.

This species was originally described by Ling-Young (**15**) as *Mucor tenellus* and subsequently transferred to *Circinella* by Zycha. The type culture NRRL *2404*, secured from Baarn for this study, produces abun-

dant upright sporangia on unbent branches as is typical of species of *Mucor*. The sporangia readily deliquesced whereas most, if not all, species of *Circinella* possess a persistent sporangial wall. When Ling-Young's isolate was mated with (+) and (−) strains of *C. umbellata*, no zygospores were produced. It seems best, therefore, to retain this species in the genus *Mucor*.

CIRCINELLA GLOMERATA van Tieghem & Le Monnier, 1873. Ann. Sci. Nat., ser. V. **17**: 310. Pl. 22, Figs. 50–53.

This species was established by van Tieghem and Le Monnier in 1873 but three years later was removed from the genus by van Tieghem and renamed *Helicostylum glomeratum* (**32**).

ZYGOSPORES

As stated above, Bainier (**1**) described and illustrated the formation of zygospores of this genus. A redescription of the process as seen in *C. umbellata* and *C. muscae* seems to be warranted in view of the deficiencies and incorrectness of some of Bainier's illustrations and data. The following description of the perfect state in *Circinella* is based principally upon *C. umbellata*, since the process is essentially similar in both species.

The perfect state of *C. umbellata* appears to be brought about in the following manner. When opposite mating types are placed together on the surface of steep agar, the two strains meet in a region of contact of substrate mycelium and from each colony margin a thin, branched aerial mycelium arises (zygophores). The zygophores are always relatively short, never being more than one-half the height of the sporangiophores. From these zygophores progametangia are produced which may be parallel to each other or distinctly bent. In *C. muscae* they are nearly straight whereas in *C. umbellata* they tend to be tong-like. There is no twisting of the progametangia about each other at their bases. The gametangia and their fusion appear to be typical of other Mucorales. The suspensors are equal in size and appear to be similar in appearance. Zygospores are scattered in a line across the surface of the medium or just above it.

After the zygospores are differentiated they assume a golden brown color. The larger zygospores are globose while the smaller ones may be either globose or ovoid. They contain numerous oil droplets which later coalesce to form a single central droplet. About this is a zone of refractive material and beyond this the outside zygospore wall proper.

The markings of the zygospore are cerebriform and can be seen only at high magnifications. At lower magnifications the wall appears to be almost smooth. Sometimes the zygospore extends a slight distance out into the suspensor; this region also becomes pigmented and heavy-walled (FIG. 1F, G). All isolates of *C. umbellata* mated freely with the opposite mating type, and one can conclude the species is heterothallic. Bainier indicated a homothallic condition in his illustrations of the zygospore, but this appears to be a misinterpretation of the actual process. From the nature of the zygospore there is even more evidence that the decision made by van Tieghem and Le Monnier (**34**) to separate *Circinella* from *Mucor* was correct.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Thomas G. Pridham of this laboratory for kindly reviewing the manuscript. They also wish to express their appreciation to Miss Edith Cash, Plant Industry Station, Beltsville, Maryland, for preparing the Latin description of *C. linderi*. They should also like to acknowledge the help of the many individuals who have so generously contributed cultures for this study.

SUMMARY

A taxonomic study of the genus *Circinella* has been made. A key is presented for the identification of the eight recognized species, including one new species, *C. linderi*. Zygospores of *C. muscae* and *C. umbellata* are described and illustrated. Czapek's solution agar supplemented with 1% corn steep liquor affords a very excellent substrate for mating compatible strains of this genus.

NORTHERN UTILIZATION RESEARCH BRANCH
AGRICULTURAL RESEARCH SERVICE
U. S. DEPARTMENT OF AGRICULTURE
PEORIA, ILLINOIS

LITERATURE CITED

1. **Bainier, M. G.** 1903. Sur quelques espèces de Mucorinées nouvelles ou peu connues. Bull. Soc. Mycol. Fr. **19**: 153–172. Pls. 6–7.
2. **Berkeley, M. J. and C. E. Broome.** 1880. List of fungi from Brisbane, Queensland: with descriptions of new species. Trans. Linn. Soc. London Bot., ser. II. **1**: 399–408. Pls. 45–46.
3. **Berlese, A. N. and J. B. de Toni.** 1888. Phycomyceteae. In Saccardo's Sylloge Fungorum **7**: 181–322.

4. **Blakeslee, A. F., J. L. Cartledge, D. S. Welch and A. D. Bergner.** 1927. Sexual dimorphism in Mucorales. I. Intraspecific reactions. Bot. Gaz. **84**: 27–50.
5. **Bunting, R. H.** 1929. Defective cacao. Gold Coast Dept. of Agric. Year Book. 1928 (Bull. **16**): 37–43. Pls. 1–4.
6. ——. 1929. Fungi occurring in cacao beans. Gold Coast Dept. of Agric. Year Book. 1928 (Bull. **16**): 44–57. Pls. 1–5.
7. **Cooke, M. C.** 1883. Australian fungi. Grevillea **12**: 8–21.
8. **Fischer, A.** 1892. Phycomycetes: Mucorinae. In Rabenhorst's Kryptogamenflora Deutschl. Oest. u. d. Schweiz. **1**(4): 161–310. Figs. 29–49.
9. **Hesseltine, C. W.** 1950. A revision of the Mucorales based especially upon a study of the representatives of this order in Wisconsin. 570 pp. Pls. 1–27. Ph.D. Thesis, University of Wisconsin.
10. ——. 1954. The section *genevensis* of the genus *Mucor*. Mycologia **46**: 358–366. Fig. 1.
11. **Hopkins, J. G., R. W. Benham and B. M. Kesten.** 1930. Asthma due to a fungus—*Alternaria*. Jour. Am. Med. Assoc. **94**: 6–10. Fig. 1.
12. **Lendner, A.** 1905. Deux mucorinées nouvelles. Bull. Herb. Boissier, ser. II. **5**: 198–199.
13. ——. 1908. Les Mucorinées de la Suisse. 180 pp. Pls. 1–3 and figs. 1–59.
14. ——. 1913. Notes mycologiques. Bull. Soc. Bot. Genève, ser. II. **5**: 29–35. Figs. 1–3.
15. **Ling-Young, M.** 1930. Étude biologique des phénomènes de la sexualité chez les mucorinées. Rev. Gen. Bot. **42**: 730–752. Figs. 29–36.
16. **Mason, F. A.** 1921. Micro-organisms in the leather industries. I. A systematic arrangement of the fungi mentioned in the literature of leather technology. Bull. Bur. Bio-Tech. **3**: 67–78.
17. **Migula, W.** 1910. Kryptogamenflora Deutschl., Öst. u. d. Schweiz **3**(1): 181–231. Pls. 1–9.
18. **Moreau, F.** 1913. Une nouvelle espèce *Circinella*: *C. conica* sp. nov. Bull. Soc. Mycol. Fr. **29**: 339–340. Figs. a–f.
19. **Murray, H. C. and D. H. Peterson.** 1952. Oxygenation of steroids by Mucorales fungi. U. S. Patent No. *2,602,769*.
20. **Naganishi, H. and T. Kojiro.** 1942. Jour. Ferm. Tech. **20**: 408–414. Pls. 1–4. [In Japanese.]
21. **Naumov, N. A.** 1939. Clés des Mucorinées. Paul Lechevalier, Paris. 137 pp. Figs. 1–82.
22. **Raper, K. B. and C. Thom.** 1949. A Manual of the Penicillia. Williams and Wilkins Co., Baltimore. 875 pp. Figs. 1–172.
23. **Reese, E. T., H. S. Levinson, Mary H. Downing and W. L. White.** 1950. Quartermaster Culture Collection. Farlowia **4**: 45–86.
24. **Reinhardt, M. O.** 1927. Mykologische Mitteilungen. Ber. Deut. Bot. Ges. **45**: 131–138. Fig. 1.
25. **Ridgway, R.** 1912. Color standards and color nomenclature. Pls. 1–53. Washington, D. C.
26. **Saito, K.** 1906. Mikrobiologische Studien über die Soyabereitung. Centlb. f. Bakt. II. **17**: 152–161. Pls. 1–5. Figs. 1–10.
27. **Schostakowitsch, W.** 1897. Vertreter der Gattung *Mucor* in Ost-Sibirien. Ber. Deut. Bot. Ges. **15**: 471–474. Figs. 1–13.

28. **Schroeter, J.** 1886. Mucorinei. In Cohn, Kryptogamen-Flora von Schlesien. **3**(2): 198–217.
29. **Smith, G.** 1951. Some new species of moulds and some new British records. Trans. Brit. Mycol. Soc. **34**: 17–22. Pls. 1–2, figs. 1–8.
30. **Sorokine, N.** 1870. Recherches sur la développément du *Helicostylum muscae* sp. nov. Bull. Soc. Imp. d. Nat. d. Moscou **43**: 256–262. Figs. 1–7.
31. **van Tieghem, P.** 1875. Nouvelles recherches sur les Mucorinées. Ann. Sci. Nat., ser. VI. **1**: 5–175. Pls. I–IV, figs. 1–177.
32. ——. 1876. Troisiéme mémoire sur les Mucorinées. Ann. Sci. Nat., ser. VI. **4**: 312–398. Pls. X–XIII, figs. 1–113.
33. —— **and G. Le Monnier.** 1872. Sur le polymorphisme du *Mucor mucedo*. Compt. Rend. Acad. Sci. **74**: 997–1001.
34. ————. 1873. Recherches sur les Mucorinées. Ann. Sci. Nat., ser. V. **17**: 261–399. Pls. XX–XXV.
35. **Waksman, S. A.** 1943. Process for the production of fumaric acid. U. S. Patent No. 2,326,986.
36. **Zycha, H.** 1935. Mucorineae. In Kryptogamenflora d. Mark Brandenburg **6a**: 1–264. Figs. 1–114.

PERENNIAL POLYPORES OF NORTH AMERICA III. FOMES WITH CONTEXT WHITE TO ROSE

JOSIAH L. LOWE

This paper concludes the study of the perennial pileate polypores of North America, a part of which, the species with strongly colored context, has already been treated (Lowe, **1952**, **1954**). The temperate zone species have been restudied by several modern mycologists and are well known; the tropical species, on the other hand, need reevaluation with particular reference to the microscopic characters. This paper considers the species with pale context that were retained in the genus *Fomes* by Murrill (**1907–08**; **1914**; **1915a**, **b**, **c**).

The concepts of the species are based, for the most part, on study of type and other material as cited. Seven species (*Fomes annosus*, *F. connatus*, *F. fraxineus*, *F. officinalis*, *F. pinicola*, *F. roseus*, and *F. unita*) are widely distributed and their identities conform with the concepts current in American and European mycology. The microscopic characteristics were obtained from free-hand sections mounted in 2 percent potassium hydroxide solution.

In these species there are 4 rather homogeneous groups. *Fomes dochmius*, *F. feei*, *F. roseus*, *F. sagraeanus*, and *F. subroseus* form one group, *F. auberianus* and *F. ulmarius* another, *F. connatus* and *F. nobilissimus* a third, and *F. sulcatus* and *F. ligneus* are so similar that their separation is rather doubtfully justified. The remaining species appear to be quite distinct from each other. This paper considers 53 species and recognizes 22 as valid, and 3 new combinations are made.

The distribution of common, widespread species in the United States, Canada, and Alaska is adapted from Overholts (**1953**). The range of the rarer species is based on cited specimens, the loan of which is gratefully acknowledged and is indicated as follows: the National Fungus Collection, Plant Industry Station, at Beltsville, Maryland, by (BPI), at which, as a collaborator, a part of the work was done; the Farlow Cryptogamic Herbarium at Cambridge, Massachusetts, by (FH); the Royal Botanic Gardens at Kew, England, by (K); the New York Botanical Garden at New York City, by (NY); and the Muséum National d'Histoire Naturelle, Laboratoire de Cryptogamie at Paris, France, by

(PC). Other herbaria are also identified by the symbols recommended by Lanjouw and Stafleu (**1952**).

KEY TO THE SPECIES

1a. Context pink or rose, sometimes drying pale wood color
  2a. Pores 2–3 per mm
    3a. Pileus convex to ungulate, becoming quite large; context hyphae 2–4 μ in diameter ..... *F. rubritinctus*
    3b. Pileus applanate; context hyphae mostly 4–6 μ in diameter *F. sagraeanus*
  2b. Pores 3–8 per mm
    4a. Upper surface red-laccate in the older portion ..... *F. hemileucus*
    4b. Upper surface not laccate, usually not red
      5a. Spores ovoid to subglobose ..... *F. fraxineus*
      5b. Spores cylindrical to ellipsoid
        6a. Pores 3–5(–6) per mm
          7a. Spores cylindrical, straight, 2–3 μ in diameter .... *F. roseus*
          7b. Spores cylindrical, sometimes allantoid, 1.5–2.5 μ in diameter ..... *F. subroseus*
        6b. Pores 5–8 per mm
          8a. Pale brownish above, darkening with age, context usually flesh color, the hyphae mostly thin-walled; spores usually somewhat pointed at the ends ..... *F. feei*
          8b. Black above from the first; context usually pinkish-tan, the hyphae thick-walled to solid; spores oblong-ellipsoid, not pointed ..... *F. dochmius*

1b. Context white to cream or pale yellowish or brownish
  9a. Context hyphae septate
    10a. Pores 5–9 per mm
      11a. Context hyphae thin-walled, often collapsed in dried specimens, septa inconspicuous ..... *F. ulmarius*
      11b. Context hyphae not collapsing, uniform in diameter, conspicuously septate ..... *F. auberianus*
    10b. Pores 2–5 per mm
      12a. Sporophore small; pores 4–5 per mm; spores 4.5–5 × 3–4 μ or 3–4 μ in diameter ..... *F. connatus*
      12b. Sporophore very large; pores 2 per mm (smaller when dry); spores 6–7 × 3.5–4 μ ..... *F. nobilissimus*
  9b. Context hyphae nonseptate, at least the principal hyphae
    13a. Spores cylindrical to narrow-ellipsoid
      14a. Spores narrow-ellipsoid with one end attenuate; sporophore large
        15a. Context hyphae mostly 2–4 μ in diameter ..... *F. sulcatus*
        15b. Context hyphae 4–8 μ in diameter ..... *F. ligneus*
      14b. Spores cylindrical; sporophore small ..... *F. scutellatus*
    13b. Spores ellipsoid to globose
      16a. Spores 7–13 × 5–8 μ
        17a. Sporophore becoming large, more or less rimose; spores 7–11 μ long ..... *F. fraxinophilus*
        17b. Sporophore remaining small, not rimose above; spores 10–13 μ long, truncate at one end ..... *F. ohiensis*

16b. Spores smaller, 4–7 × 2–5 μ
18a. Context bitter, white
19a. Sporophore sessile, becoming large; hyphae 3–5 μ in diameter ..... *F. officinalis*
19b. Sporophore resupinate or narrowly reflexed; hyphae 1.5–3 μ in diameter ..... *F. unita*
18b. Context tasteless or slightly resinous, white or cream to light brown, tough or corky
20a. Sporophore thick, usually sessile; spores 5–7 × 3–4 μ .. .. *F. pinicola*
20b. Sporophore thin, usually mostly resupinate; spores 3.5–5 × 2–4.5 μ
21a. Pores 2–4 per mm; spores 3.5–4.5 μ wide; northern in distribution ..... *F. annosus*
21b. Pores 8–9 per mm; spores 2.5–3.5 μ wide; tropical in distribution ..... *F. contrarius*

ANNOTATED LIST OF SPECIES

acgerita Fries (*Polyporus*). Described from Mexico. No specimen is now in the Fries Herbarium (J. Eriksson, letter). Fries (**1851**, p. 70) stated that it was related to *Polyporus supinus* Swartz ex Fries and *P. microporus* Swartz; Murrill (**1908**, p. 100) believed it allied to *Fomes geotropus*, and Lloyd (**1915**, p. 278) thought the description indicated *F. laricis*.

albogriseus Peck (*Fomes*). A synonym of *F. officinalis*. (NYS-type.)

amarus (Hedgc.) Murr. (*Fomes*). An annual species which should be referred to *Polyporus*. (BPI-type.)

annosus (Fries) Cooke (*Fomes*). Resupinate to sessile, the pileus brownish and sulcate above, up to 10 × 12 × 3 cm; pores 2–4 per mm; context whitish, with a thin dark layer above, the principal hyphae nonseptate; cystidia none; spores ovoid, 4.5–5 × 3.5–4.5 μ. On wood of coniferous trees from the United States and southern Canada; associated with a white pocket rot. *Polyporus irregularis* is a synonym.

arctica Berk. (*Trametes*). An herbarium name usually used synonymously with *F. roseus*.

auberianus (Mont.) Murr. (*Fomes*). Sessile, the pileus applanate, up to 5 × 7 × 1 cm, tan to sordid reddish-brown and indistinctly zonate above; pore surface rather dark in older portions, the pores 8–9 per mm; context pale yellowish, silky where broken, the hyphae thin-walled but not collapsing, conspicuously septate, uniformly 3–5 μ in diameter; hymenium very poorly represented on type, apparently without cystidia; spores not seen. Type on wood in Cuba; further distribution very uncertain.

The specific identity of this species, and of the very similar *F. ulmarius* (*F. geotropus* of American mycology), cannot be considered as satisfactorily established. These belong to a complex of abundant and highly variable species which have been described repeatedly as new, and have figured in the literature most commonly as *Polyporus microporus* Swartz ex Fries and *Fomes lignosus* (Klotzsch) Bres. (PC-type; BPI-isotype.)

bistratosus (Berk. & Cooke) Cooke (*Fomes*). Reported by Annie L. Smith from the West Indies. This specimen (Elliott *1283*, BM) is resupinate and therefore outside the scope of this paper; it does not appear to differ from the type of *Poria vincta* (Berk.) Cooke.

carnea Amer. aut., non Bl. & Nees (*Trametes*). Name used for *F. subroseus*.

circumstans Morgan (*Polyporus*). According to Lloyd (**1915**, p. 279) a synonym of *F. fraxinophilus*, and he states that Morgan admitted it was the same as *F. ellisianus*. Type specimen not found (not at BPI, FH, IA, MO, NY, NYS).

connatus (Weinm.) Gill. (*Fomes*). Usually sessile, the pileus convex to subungulate, white above, in age darkening and usually covered with moss or algal growth, up to 10 × 15 × 4 cm; pores 4–5 per mm; context white, the hyphae septate; tubes distinctly stratified; cystidia capitate-incrusted, easily confused with other crystalline bodies abundant in the hymenium; spores ellipsoid to globose, 4.5–5 × 3–4 μ or 3–4 μ in diameter. On the wood of deciduous trees from Nova Scotia to Georgia westward to Arkansas and Manitoba; associated with a soft white butt rot. *Fomes populinus* is a synonym.

contrarius Berk. & Curt. (*Fomes*). Nearly resupinate, the pileus reflexed at the margin, above darkening to more or less black, glabrous, up to 12 × 12 × 0.3 cm; pores 8–9 per mm; context whitish, the hyphae nonseptate, 3–6 μ in diameter; tubes distinctly stratified; cystidia lacking; spores short-oblong with rounded ends to oval, 4–5 × 2.5–3.5 μ. On wood in Cuba, known only from the type material. (K-type; NY- and BPI-isotypes.)

dochmius (Berk. & Broome) Cooke (*Fomes*). Effused-reflexed to sessile, the pileus black above, in age fading to gray, up to 10 × 13 × 2 cm; pore surface pale, the pores 5–8 per mm; context pinkish tan, sometimes fading to cream or wood color, the hyphae thick-walled to apparently solid, nonseptate; cystidioles present; spores oblong-ellipsoid, 4.5–6 × 2–2.5 μ. On the wood of deciduous trees from Guatemala (BPI), British Honduras (NY), Nicaragua (BPI), Costa Rica (NY); Panama

(BPI), Jamaica (FH, NY, BPI), and Cuba (FH, NY, BPI); associated with a brown rot. *Fomes subferreus* is a synonym.

ellisianus Anderson (*Fomes*). A synonym of *F. fraxinophilus;* the name applied to strongly rimose forms on *Shepherdia* (NY-type.)

feei (Fries) Lowe, comb. nov. (*Fomes*). *Polyporus feei* Fries, Linnaea **5**: 518. 1830. Sessile, the pileus pale brownish above, darkening in age, up to 6 × 10 × 2 cm; pore surface pale rose, the pores 5–6 per mm; context flesh-color or pale brown, the hyphae mostly thin-walled, nonseptate; cystidia none; spores oblong-ellipsoid to ellipsoid, usually somewhat pointed at the ends, 5–8 × 2–2.5 μ. On the wood of deciduous trees in Florida (NY), Mexico (NY), El Salvador (FH, NY), British Honduras (FH), Jamaica (NY), Cuba (NY), French Guiana (PC-type, K- and NY-isotypes), Brazil (NY), and Colombia (NY). This plant is Murrill's concept of *F. sagraeanus.*

ferreus Berk. (*Polyporus*). Reported from Cuba by Berkeley and Curtis. This specimen (K—Wright No. *813*) is fragmentary, sterile, and scarcely determinable. It may be the pale form of *F. melanoporus* which has been named *F. cinerea* Rick. Lloyd (**1915**, pp. 221, 223) says the collection should be referred to *F. dochmius.* Isotype material in the Lloyd Herbarium (BPI) is *F. dochmius,* as is isotype material in the Curtis collection (FH). It appears that the original collection (Wright 813) may have been a mixed collection.

fraxineus (Bull. ex Fries) Cooke (*Fomes*). Sessile, the pileus more or less reddish above, with a thin hard crust; pores 4–6 per mm; context flesh-colored, often fading on drying; cystidia none; spores ovoid to subglobose, 6–7 × 5–6 μ. On the wood of deciduous trees from Quebec to Florida and westward to the prairies; associated with a white rot. *Polyporus induratus* is a synonym.

fraxinophilus (Peck) Sacc. (*Fomes*). Sessile, the pileus soon black above, usually somewhat rimose with age, up to 20 × 30 × 10 cm; pores 2–3 per mm; context white to light brown, the hyphae nonseptate; spores ellipsoid to ovoid, often truncate at one end, 7–11 × 5–8 μ. Usually on ash, from Quebec south to Tennessee, westward to the prairies and in the Rocky Mountains; associated with a white mottled rot. *Polyporus circumstans* and *P. ellisianus* are synonyms. (NYS-type.)

geotropus Cooke (*Fomes*). Specimens seen from the southern United States and tropical North America agree with *F. ulmarius* as represented by specimens from western Europe. The hymenium of the type of *F. geotropus* from Demerara, British Guiana, in South America, is in poor condition, but the species appears to lack cystidia and has con-

text hyphae of a quite different nature than in *F. ulmarius*. (K-type; BPI-isotype.)

hemileucus (Berk. & Curt.) Cooke (*Fomes*). Sessile, the pileus red-laccate above in the older portion, up to 6 × 9 × 2 cm, the margin similar or concolorous with the pinkish-brown pore surface; pores 5–7 per mm; context pale pinkish-brown, the hyphae mostly 4–7 mm in diameter; hymenial elements not seen. Known only from the original material from Cuba, of which Wright No. *167* (K; FH) is designated the lectotype. Wright Nos. *417* (K; FH), *419* (K), and *423* (K; FH) are the same fungus; No. *407* (K; FH), noted in the original description as a "not yet laccate" specimen, appears to be a young sporophore of *Fomes feei*, and No. *428* (FH) is a resupinate sterile specimen, wholly unrelated, with all the known characters of the type of *Poria palmicola* (Berk. & Curt.) Cooke. Sporophores are similar to those of *F. dochmius*, but differ in the laccate surface.

hornodermus Mont. (*Polyporus*). A synonym of *Fomes ligneus*. (PC-type; S- and BPI-isotypes.)

incrustatus (Fries) Cooke (*Fomes*). Described (Fries, **1851**, p. 60) from Costa Rica. It is not now in the Fries Herbarium (Eriksson, letter), and its relationships are not known.

induratus Lloyd (*Polyporus*). A synonym of *Fomes fraxineus*. (BPI-type.)

irregularis Underwood (*Polyporus*). A synonym of *Fomes annosus*. (NY-type.)

laminatus C. L. Smith (*Fomes*). A *nomen nudem* proposed in C. L. Smith's Central American Fungi No. *138*, which later was made the type of *F. rubritinctus*. (BPI; NY.)

laricis Jacq. ex Murr. (*Fomes*). A synonym of *F. officinalis*.

ligneus (Berk.) Cooke (*Fomes*). Usually sessile, the pileus dark above, up to 15 × 12 × 5 cm; pore surface pale, the pores 4 per mm; context cream to pale wood color, the hyphae nonseptate, 4–8 μ in diameter; cystidia none; spores narrow-ellipsoid, somewhat attenuate at one end, 8× 3–4 μ. On wood in Mexico (BPI), Nicaragua (NY), Costa Rica (NY), Cuba (NY), Dominican Republic (BPI), Grenada (NY), Brazil (NY), Paraguay (NY), Mauritius (K-type; BPI-isotype), Philippine Islands (NY), and New Zealand (BPI). *Polyporus hornodermus* is a synonym.

lignosus Klotzsch (*Polyporus*). A tropical species said to be distributed around the world. It is in the complex of species that includes *F. auberianus* and *F. ulmarius;* its exact identity however is quite uncertain.

marginatus (Pers.) Gill. (*Fomes*). As used in America a synonym of *F. pinicola.*

martius (Berk.) Cooke (*Fomes*). Lloyd (**1915**, p. 215) reports this from Central America and the West Indies. Specimens from North America so named have not been seen. The type specimen from Brazil does not appear to differ in any essential way from *F. igneus.* (K-type; BPI-isotype.)

meliae Underwood (*Polyporus*). An annual species, which infrequently may persist for another year or two. (NY-type.)

nobilissimus (W. B. Cooke) Lowe, comb. n. (*Fomes*). *Oxyporus nobilissimus* W. B. Cooke, Mycologia **41**: 444. 1949. Sessile, the pileus ungulate, white above, densely strigose, becoming very large, up to 140 × 95 × 100 cm and 300 pounds in weight when fresh; pore surface pale, the pores averaging 5 per mm when dry, "2 per mm" (Cooke, from a fresh specimen); context more or less white, the hyphae septate; tubes in distinct layers; cystidia present; spores subglobose, 6–7 × 3.5–4 μ. On the wood of coniferous trees in Washington and Oregon; associated with a brown rot. (BPI; MICH-type.)

officinalis (Vill. ex Fries) Faull (*Fomes*). Sessile, the pileus ungulate, pale above, up to 12 × 25 × 30 cm; pore surface pale, the pores averaging 3–4 per mm; context white, friable and extremely bitter in dry specimens, the hyphae variable, nonseptate or septate or clamped, mostly 3–5 μ in diameter; cystidioles hairlike; spores ellipsoid to ovoid, 4–5.5 × 3–4 μ. On the wood of coniferous trees from Ontario westward to Arizona and California and northward to Alaska; associated with a brown trunk rot. *Fomes albogriseus* and *F. laricis* are synonyms.

ohiensis (Berk.) Murr. (*Fomes*). Sessile, the pileus above soon dark at base but remaining white at the margin, up to 2.5 × 3 × 1 cm; pore surface pale, the pores 3–5 per mm; context white to pale brown, the hyphae mostly nonseptate; cystidia none; spores ellipsoid to ovoid, with one end truncate, 10–13 × 6–8 μ. On the wood of deciduous trees from Ontario and Massachusetts south and west to North Carolina and the prairies, and in Florida (NY), Jamaica (NY) and Cuba (NY); associated with a white rot. Murrill's subtropical collections called *F. turbinatus* belong here. (K-type; NY-isotype.)

perpusillus Pers. (*Polyporus*). Isotype material (NY) is surely referable in synonymy to *F. scutellatus,* as Bresadola (**1916**, p. 226; **1926**, p. 80) has referred them; not to *F. ohiensis* as Murrill (**1907**, p. 29) tentatively suggests. (NY-isotype.)

pinicola (Swartz ex Fries) Cooke (*Fomes*). Usually sessile, the pileus darkening above to black, up to 15 × 20 × 10 cm, the margin often

pale or reddish-resinous; pore surface pale, the pores 3–5 per mm; context cream to light brown, the hyphae nonseptate; cystidia hairlike; spores ellipsoid to ovoid, 5–7 × 3–4 μ. On the wood of coniferous or occasionally of deciduous trees from New Brunswick to North Carolina west to California and Alaska, and in Mexico (Lloyd, **1915**, p. 219) and Puerto Rico (BPI); associated with a brown cubical rot. *Fomes ungulatus, Polyporus marginatus* and *P. ponderosus* are synonyms.

plebius var. *cubensis* Berk. (*Polyporus*). The variety was based on five collections from Cuba, of which 3 (Nos. *398, 400, 408*) are *Polyporus supinus* Swartz ex Fries, No. *401* is *P. vinosus* Berk., and No. *399* is, apparently, a young specimen of *Fomes feei*. (All at K.)

ponderosus von Schrenk (*Polyporus*). A synonym of *F. pinicola*. (NY-type.)

populinus (Schum.) Cooke (*Fomes*). As used in America, a synonym of *Fomes connatus*.

roseus (Alb. & Schw. ex Fries) Cooke (*Fomes*). Sessile, the pileus becoming black above, up to 7 × 10 × 3 cm; pore surface pinkish or rosy, the pores 3–6 per mm; context pinkish or rose; cystidia none; spores straight, cylindrical, 5–8 × 2–3 μ. On the wood of coniferous trees from Quebec and Maine westward to Ontario and New York, and in the West from New Mexico northward to British Columbia; associated with a brown rot. It is similar to *F. subroseus* except for the straight, thicker spores. *Trametes arctica* is a synonym.

rubritinctus Murr. (*Fomes*). Sessile, the pileus convex to ungulate, reddish-brown above, up to 12 × 15 × 10 cm; pore surface brownish, the pores 2–3 per mm; context pale wood-color, the hyphae nonseptate, 2–4 μ in diameter; cystidia none; spores absent on type, on other material oblong-ellipsoid, 5–7 × 2–2.5 μ. Presumably on wood, known only from Nicaragua, distributed as No. *138* in C. L. Smith's Central American Fungi.

Bresadola (Studi Trentini II, **7**: 80 [or 30 in reprint]. 1926) places this species in synonymy with *Polyporus scleromyces* Berk. & Curt., in error surely, as that species is distinctly different. *F. laminatus* is a synonym. (NY-type.)

rudis Lév. (*Polyporus*). Described from Guadeloupe; specimen not now at Paris (PC). Name changed to *P. subfulvus* by Cooke. Murrill (**1907**, p. 45) says that the descriptions suggest faded specimens of *Polyporus corrugatus* Pers. Bresadola (**1916**, p. 227) says it is a synonym of *P. supinus* Swartz ex Fries.

rufo-flavus Berk. & Curt. (*Polyporus*). Isotype material (FH) appears to be an annual plant in the same species complex as *F. auberianus*.

sagraeanus (Mont.) Murr. (*Fomes*). Sessile, the pileus applanate to conchate, brownish pink above, subsilky, narrowly and faintly zonate, up to 8 × 14 × 0.7 cm; pore surface dark pinkish-brown, the pores 3 per mm; context brownish pink, the hyphae nonseptate, mostly 4–6 μ in diameter; cystidia and spores not seen. Known only from the type specimen from Cuba (PC), which is doubtfully referable to *Fomes*, as only one layer of tubes is present.

scutellatus (Schw.) Cooke (*Fomes*). Sessile, the pileus becoming dark above, up to 1.5 × 2 × 0.5 cm; pore surface pale, the pores averaging 4–5 per mm; context white to light brown, the hyphae mostly nonseptate; cystidia none; spores cylindrical, 8–9 × 2.5–3.5 μ. On the wood of deciduous trees, usually *Alnus*, from Quebec to Florida and northwestward to British Columbia; associated with a white rot. *Polyporus perpusillus* is a synonym. (PH-type.)

scutellatus var. *novaboracensis* Sacc. (*Fomes*). A variety which does not seem to differ from the usual concept of the species.

subferreus Murr. (*Fomes*). A synonym of *F. dochmius*. (NY-type.)

subfulvus Cooke (*Polyporus*). Change of name by Cooke for *Polyporus rudis*.

subroseus (Weir) Overh. (*Fomes*). Effused-reflexed to sessile, the pileus pinkish to rose color above, darkening in age to black, up to 5 × 7 × 0.7 cm; pore surface pinkish or rosy, the pores 3–5 per mm; context pinkish to rose, the principal hyphae nonseptate; cystidia none; spores cylindrical, sometimes allantoid, 5–8 × 1.5–2.5 μ. On the wood of coniferous or rarely of deciduous trees from Quebec to Florida westward to California and British Columbia; associated with a brown rot. The species is very similar to *F. roseus*, from which it differs in the narrower, often curved spores. *Trametes carnea* is a synonym.

sulcatus Cooke (*Fomes*). Sessile, the pileus dark above, up to 11 × 13 × 5 cm; pore surface pale, the pores 4–6 per mm; context pale to brownish, the hyphae nonseptate, mostly 2–4 μ in diameter, rarely a few to 6 μ; cystidia none or perhaps as small capitate-incrusted hymenial structures; spores narrow-ellipsoid with one end attenuated, 5–11 × 3–5 μ. On wood from Nicaragua (NY), Costa Rica (NY), Cuba (BPI), Grenada (NY; BPI); widely distributed in the tropics; associated with a brown mottled rot.

turbinatus (Pat.) Murr. (*Fomes*). All specimens from North America so named are here referred to *F. ohiensis*. The type was described from Venezuela. (FH-type.)

ulmarius (Sow. ex Fries) Cooke (*Fomes*). Effused-reflexed to sessile, the pileus applanate to convex, pale above, up to 15 × 25 × 8

cm; pore surface more or less pink, on drying sometimes grayish, the pores 5–8 per mm; context white to cream, the hyphae thin-walled, often collapsed, inconspicuously septate; cystidia bulbous, 4–11 μ in diameter; spores globose or nearly so, 5–8 μ in diameter. On dead wood or from wounds in living hardwood trees from Georgia to Texas and Arkansas; associated with a soft white rot. This is *F. geotropus* of American mycology.

ungulatus Schaeff. ex Sacc. (*Fomes*). As used by Murrill, a synonym of *F. pinicola*.

unita (Pers.) Lowe, comb. nov. (*Fomes*). *Polyporus unitus* Pers., Myc. Europ. **2**: 93. 1825. Usually resupinate, rarely reflexed up to 1 cm, the pileus brownish black to black above, the pore surface cream or pinkish, the pores 5–8 per mm; context white to slightly brownish, the hyphae nonseptate, 1.5–3 μ in diameter; cystidia none; spores oblong-ellipsoid to subglobose, often truncate, 4–7 × 2.5–5 μ. On the wood of deciduous or rarely of coniferous trees from Quebec to Georgia westward to the prairies and in Colorado and California; associated with a white rot. The sporophores are usually resupinate, and pileate specimens have been seen from North Carolina and Georgia (Lowe, *3861, 6000*).

SUPPLEMENT

Additions and corrections to the species with brown or orange context treated in previous papers (Lowe, **1952, 1954**).

calvescens (Berk.) Cooke (*Fomes*). Isotype material from Louisiana (BPI) is a *Trametes*-like sporophore unknown to me, but it is certainly unrelated to *Polyporus gilvus* (Schw.) Fries, as Saccardo (Syll. Fung. **6**: 120–121. 1888) states.

chilensis (Fries) Cooke (*Fomes*). The specimen issued as No. *113* in C. L. Smith's Central American Fungi is *F. linteus*. (BPI.)

cinerea Rick (*Fomes*). Apparently a pale form of *F. melanoporus*, according to the type (from Brazil) and other collections from the West Indies in the Lloyd Herbarium. (BPI.)

crocitinctus Berk. & Curt. (*Polyporus*). This species, placed in *Fomes* by Cooke, has an annual sporophore. (FH and BPI-istoypes.)

demidoffii (Lév.) Cooke (*Fomes*). Type specimen (PC; BPI-isotype) differs in no way from the type of *F. juniperinus* and it is the prior name.

endotheius (Berk.) Cooke (*Fomes*). Reported from Trinidad (Baker and Dale, Fungi of Trinidad and Tobago. Commonwealth Myc. Inst., Myc. Papers **33**: 77. 1951). The specimen, Seaver No. *3491*, is *F. sweitenicae*. (BPI; NY.)

excavatus (Berk.) Cooke (*Fomes*). Described as a variety of *F. fomentarius* from British America. The type material is typical of the species. (K-type.)

extensus (Lév.) Cooke (*Fomes*). The rot ascribed to this fungus by Long (Torrey Bot. Club Bul. **66**: 625. 1939) should be referred instead to *Fomes pseudosenex* (Murr.) Sacc. & Trott., as Long's specimens at BPI are the latter species.

korthalsii (Lév.) Cooke (*Fomes*). Reported by Léveille from Guadeloupe (Ann. Sci. Nat. Bot. III, **5**: 133. 1846). The specimen (PC) is sterile but appears certainly referable to *Polyporus licnoides* Mont. The specimen reported by Duss (Enum. Meth. Champ. Guadeloupe & Martinique, p. 34. **1903**) is not at Paris (PC). Lloyd (**1915**, p. 277) says the determinations by Bresadola and Léveille are *Fomes senex* (Nees & Mont.) Cooke.

portoricensis Overh. (*Fomes*). A synonym of *F. melanodermus* var. *tomentosus* Bres. (NY-type.)

roburneus (Fries) Cooke (*Fomes*). The specimen reported by Lloyd (Myc. Writ. **7**: 1130 and 1155. 1922) appears to be typical *Fomes igniarius*. (BPI.)

rufo-atratus (Berk.) Cooke (*Fomes*). Reported by Ellis and Macbride from Nicaragua (Lab. Nat. Hist. Univ. Iowa Bul. **3**: 193. 1896). The specimen in C. L. Smith's Central American Fungi (No. *398?*) appears to be a stipitate Polyporus. (BPI.)

rugulosus (Lév.) Cooke (*Fomes*). Reported from Puerto Rico by Bresadola *et al.* (Engler's Bot. Jahrb. **17**: 494. 1893). No specimen is now in the Bresadola Herbarium at Stockholm.

sanjanii Lloyd (Fomes). Mycol. Writ. C. G. Lloyd **6**: 885 and plate 129, f. 1528. 1919. A species very similar to *F. badius*, with pores 2 per mm, but spores smaller, brown, smooth, oblong with rounded ends, 5×3–$4\ \mu$. Type, Lloyd Herb. *16103*, only specimen known, from the island of St. John. (BPI.)

subendotheius Bres. (*Fomes*). Type from Curaçao, Dutch West Indies. A synonym of *F. badius* Berk. (S-type; BPI-isotype.)

weirianus Bres. (*Fomes*). Isotype material (BPI) appears to be the same as *F. praerimosus* (Murr.) Sacc. & D. Sacc. Type material was not found in the Bresadola Herbarium at Stockholm.

COLLEGE OF FORESTRY,
STATE UNIVERSITY OF NEW YORK,
SYRACUSE, N. Y.

LITERATURE CITED

Bresadola, J. 1916. Synonymia et adnotanda mycologica. Ann. Mycol. **14**: 221–241.

——. 1926. Selecta mycologica II. Studi Trentini, ser. *2*, **7**(1): 51–81 (reprint 1–31).

Fries, E. 1851. Novae symbolae mycologicae. Actis R. Soc. Upsal., Ser. III, **1**: 17–136.

Lanjouw, J., and F. A. Stafleu. 1952. Index herbariorum. Part 1. The herbaria of the world. Utrecht, Netherlands.

Lloyd, C. G. 1915. Synopsis of the genus *Fomes*. Mycological Writings of C. G. Lloyd **4**: 209–288.

Lowe, J. L. 1952. Perennial polypores of North America. *Fomes* with colored spores. Mycologia **44**: 228–238.

——. 1954. ————. Fomes with colored context, hyaline spores. Mycologia **46**: 488–497.

Murrill, W. A. 1907–08. Polyporaceae, in North American Flora **9**: 1–131.

——. 1914. Northern Polypores. New York, N. Y., privately printed.

——. 1915a. Southern Polypores. New York, N. Y., privately printed.

——. 1915b. Tropical Polypores. New York, N. Y., privately printed.

——. 1915c. Western Polypores. New York, N. Y., privately printed.

Overholts, L. O. 1953. The Polyporaceae of the United States, Alaska, and Canada. Univ. of Michigan Press, Ann Arbor, Michigan.

SPECIES OF PUCCINIA ON SALVIA IN EUROPE, ASIA, AND AFRICA [1]

JOHN W. BAXTER

(WITH 8 FIGURES)

This paper concludes a monograph of the species of *Puccinia* known to occur on *Salvia*. Previously, the North American (**1**) and South American (**2**) members of this group of rusts were reviewed. The present paper redescribes and redefines the six known species occurring in Europe, Asia and Africa. *Puccinia nevadensis* Syd. and *Puccinia salviae-interruptae* Maire are reduced to synonymy with *Puccinia bithynica* Magn. Neotypes are selected for *Puccinia nigrescens* Kirchn. and *Puccinia salviae* Ung.

KEY TO THE SPECIES

Teliospore pedicel thin-walled, fragile.
- Teliospore wall verrucose.....1. *P. delavayana*
- Teliospore wall smooth.
  - Pore of lower cell next to the septum.....2. *P. nigrescens*
  - Pore of lower cell next to the pedicel.....3. *P. salviae-runcinatae*

Teliospore pedicel thick-walled, persistent.
- Teliospores 12–22 × 26–48 μ.
  - Teliospores rounded or narrowed at the apex.....4. *P. nipponica*
  - Teliospores beaked or papillate at the apex.....5. *P. salviae*
- Teliospores 16–33 × 36–70 μ.....6. *P. bithynica*

1. PUCCINIA DELAVAYANA Pat. & Hariot, Bull. Soc. Myc. Fr. **21**: 84. 1905.

Spermagonia, aecia and uredia unknown. Urediospores in the telia, oblate-spheroid, 20–25 μ broad by 14–17 μ high; wall pale cinnamon-brown, yellowish or nearly hyaline, closely and finely echinulate, about 1 μ thick, pores 2 or 3, subequatorial. Telia hypophyllous, scattered,

[1] Journal Paper No. 787, of the Purdue University Agricultural Experiment Station. Contribution from the Department of Botany and Plant Pathology.

It is a pleasure to acknowledge the cooperation of the following: Dr. G. B. Cummins, Purdue University; Dr. Julian A. Steyermark, Chicago Museum of Natural History; Dr. J. R. Swallen, U. S. National Herbarium; Mr. J. A. Stevenson, Bureau of Plant Industry, U. S. Department of Agriculture; Dr. Sten Ahlner, Naturhistoriska Riksmuseet, Stockholm, Sweden; and Dr. M. Guinochet, Universite d'Alger, Alger, Algeria.

round, 0.1–0.3 mm in diameter, pulverulent, chocolate-brown; teliospores broadly ellipsoid or oblong, 20–33 × 30–43 μ, rounded at both ends, slightly or not constricted at the septum; wall light chestnut-brown, 2–3 μ thick, finely and evenly verrucose, pore of upper cell apical, capped by a broad hyaline or yellowish umbo 3–5(–7) μ thick, pore of lower cell next to the septum, with a hyaline or yellowish umbo 2–3 μ thick; pedicel hyaline, thin-walled, fragile, breaking away at or near the point of attachment.

HOSTS AND DISTRIBUTION: *Salvia* sp., China.

TYPE SPECIMEN: On *Salvia* sp., Yunnan, China, Delavay.

ILLUSTRATIONS: FIG. 1 (from type).

The verrucose sculpturing of the teliospore wall in *Puccinia delavayana* serves to distinguish it from other Old World species on *Salvia*. The species is known only from the type locality.

2. PUCCINIA NIGRESCENS Kirchn., Lotos **6**: 182. 1856.

Puccinia obtusa Schroet., Abhandl. Schles. Gesellsch. **1869**: 13. 1869.

Spermagonia amphigenous, chiefly epiphyllous, in groups, globoid, yellowish, 100–170 μ in diameter. Aecia amphigenous, aecidioid, usually in groups up to 8 mm in length along the veins, occasionally in circular groups up to 2 mm in diameter; peridial cells rhomboidal or rectangular, overlapping, 16–26 × 23–40 μ in surface view, hyaline, inner wall 3–5 μ thick, coarsely verrucose, outer wall 6–10 μ thick, finely striate; aeciospores angularly globoid, 16–23 × 16–23 μ, or oblong, 10–16 × 20–26 μ; wall pale yellow, 1 μ or less in thickness, finely and closely verrucose. Uredia amphigenous, scattered, round, 0.1–0.5 mm in diameter, pulverulent, cinnamon-brown; urediospores broadly ellipsoid or obovoid, 20–23 × 23–28 μ, globoid, 20–25 μ, or oblate-spheroid, 23–27 μ broad by 20–23 μ high; wall cinnamon-brown, prominently echinulate, 1–2 μ thick, pores 2, equatorial. Telia amphigenous, chiefly hypophyllous, scattered, round, 0.2–1.0 mm in diameter, pulverulent, blackish brown; teliospores narrowly ellipsoid or oblong, 20–30 × 30–52 μ, rounded above, rounded or narrowed below, not or slightly constricted at the septum; wall chestnut-brown, paler over the pores, smooth, 2–3 μ, thickened to 4–10 μ at the apex, pore of upper cell apical, of lower next to the septum; pedicel hyaline, thin-walled, fragile, usually broken away at the spore, occasionally up to 45 μ long.

HOSTS AND DISTRIBUTION: *Salvia amasiana* Freyn & Bornm., *S. judiaca* Boiss., *S. verticillata* L., *S. virgata* Ait.; Europe, Asia Minor.

TYPE SPECIMEN: On *Salvia verticillata*, Belgrade, Serbia, Aug. 10, 1908, N. Ranojevic (Syd. Ured. *2271*) (Neotype).

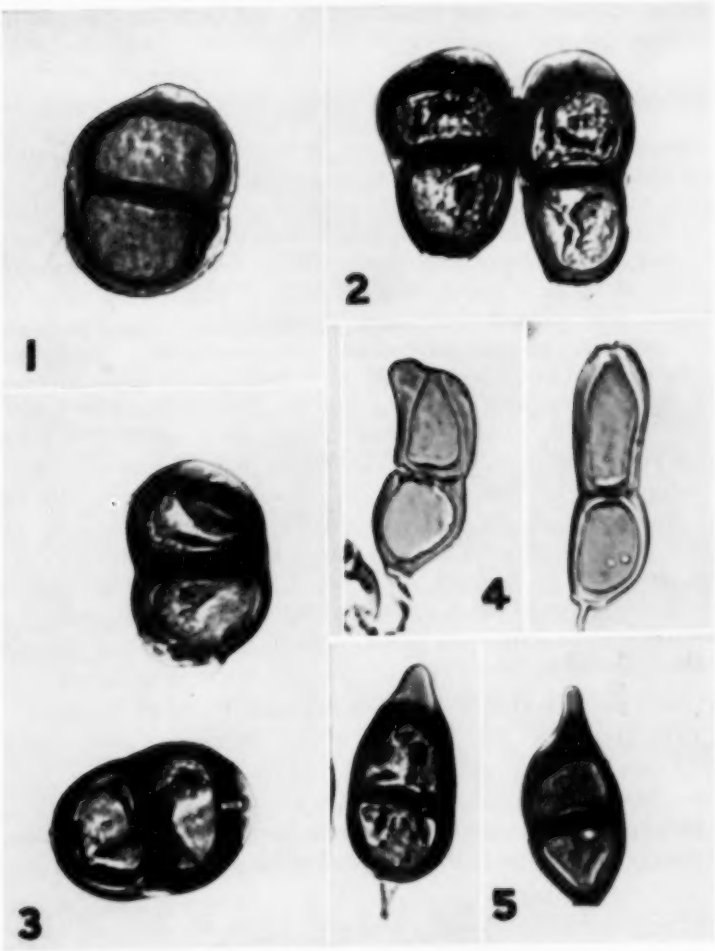


FIG. 1. Teliospore of *Puccinia delavayana* (from type), × 800. 2. Teliospores of *P. nigrescens* (from neotype), × 800. 3. Teliospores of *P. salviae-runcinatae* (from type), × 800. 4. Teliospores of *P. nipponica* (from type), × 800. 5. Teliospores of *P. salviae* (from neotype), × 800.

ILLUSTRATIONS: Fischer, Uredineen der Schweiz, p. 171, Fig. 132; Klebahn and Lindau, Kryptogamenflora der Mark Brandenburg, p. 390, Fig. 42; FIG. 2 (from neotype).

The teliospores of *Puccinia nigrescens* resemble those of a North

American species, *Puccinia caulicola* Tracy and Gall., but differ in having fragile, thin-walled pedicels.

3. PUCCINIA SALVIAE-RUNCINATAE Doidge, Bothalia **2**: 80. 1926.

Spermagonia epiphyllous, in groups, yellowish, 100–160 μ in diameter. Aecia amphigenous and caulicolous, in groups up to 5 mm across, often causing slight distortion, aecidioid; peridial cells rhomboidal or oblong, 20–25 × 24–40 μ in surface view, yellowish or hyaline, inner wall verrucose, 3–4 μ thick, outer wall finely striate, 6–7 μ thick; aeciospores globoid, oblong or ellipsoid, 16–20 × 20–30 μ, wall 1–1.5 μ thick, pale yellow or hyaline, finely verrucose. Uredia hypophyllous and caulicolous, scattered, round, pulverulent, cinnamon-brown; urediospores broadly ellipsoid or globoid and 20–23 × 20–27 μ with pores in surface view, narrowly ellipsoid or oblong and 13–17 × 20–27 μ with pores in median view; wall cinnamon-brown, 1–1.5 μ thick, moderately echinulate, pores 2, equatorial. Telia caulicolous, 0.5–1.5 mm in diameter, elliptical, somewhat compact, blackish brown; teliospores broadly ellipsoid or oblong, 23–30(–33) × 30–43(–46) μ, rounded at both ends, slightly or not constricted at the septum; wall chestnut-brown, 2–3.5 μ thick, smooth, pore of upper cell apical or subapical, of lower near the pedicel, each covered by a cinnamon-brown or yellowish umbo 2–4 μ thick; pedicel hyaline, thin-walled, fragile, occasionally attached obliquely, up to 80 μ long.

HOSTS AND DISTRIBUTION: *Salvia runcinata* L., South Africa.

TYPE SPECIMEN: On *Salvia runcinata*, Skinner's Court, Pretoria, Dist. Transvaal, South Africa, Dec. 31, 1911, Pole-Evans.

ILLUSTRATIONS: Doidge, Bothalia **2**: 81; FIG. 3 (from type).

This species is readily distinguishable from *P. nigrescens* because of the position of the pore in the lower cell of the teliospore.

4. PUCCINIA NIPPONICA Diet., Engl. Bot. Jahrb. **28**: 284. 1901.

Spermagonia unknown. Aecia and uredia lacking. Telia hypophyllous, round, 0.2–0.8 mm in diameter, scattered or in groups up to 2 mm across, compact, pulvinate, cinnamon or chestnut-brown; teliospores narrowly ellipsoid, fusiform or cylindric, 13–22 × 26–48 μ, rounded or narrowed at both ends, constricted at the septum, germinating without a resting period; wall cinnamon-brown or yellowish, frequently darker above, 1–2 μ thick in lower cell, thickened to 2–3 μ in the upper cell and to 4–7(–9) μ at the apex, smooth, pore of upper cell apical, of lower next to the septum; pedicel hyaline, thick-walled, persistent, up to 80 μ long.

HOSTS AND DISTRIBUTION: *Salvia nipponica* Miq., Japan.

TYPE SPECIMEN: On *Salvia nipponica*, Soma, Prov. Iwaki, Japan, May 8, 1899, Kusano *167*.

ILLUSTRATIONS: Sydow, Monog. Ured. **1**: 281, Fig. 282; Ito, Mycological Flora of Japan **2**: 299, Fig. 385; FIG. 4 (from type).

The teliospores of *P. nipponica* show some variation in the apical thickening of the wall. They are readily distinguishable from those of *P. salviae*, lacking the papilla or beak characteristic of the latter species.

5. PUCCINIA SALVIAE Ung., Einfluss des Bodens etc., p. 218. 1836.

Puccinia salviae-glutinosae Ces. apud Sacc. in Myc. ven. No. 130. 1873.

Spermagonia unknown. Aecia and uredia lacking. Lepto-form telia hypophyllous, scattered or in groups, round, 0.2–0.5 mm in diameter, pulvinate, indurate, yellowish or cinnamon-brown; lepto-form teliospores ellipsoid or fusiform, 12–20 × 26–43 μ, rounded or narrowed at both ends, not or slightly constricted at the septum, germinating without a resting period; wall hyaline or pale yellow, 1–2 μ thick, thickened apically to 4–10 μ, usually papillate or beaked at the apex, smooth, pore of upper cell apical or subapical, of lower next to the septum; pedicel hyaline, thin-walled, persistent, up to 90 μ long. Resting telia amphigenous and caulicolous, scattered or in circular groups, round, 0.2–1.0 mm in diameter on leaves, up to 4 mm long on stems, compact, pulvinate, chestnut or chocolate-brown; resting teliospores ellipsoid or broadly fusiform, 16–23 × 30–50 μ, rounded or narrowed at both ends, not or slightly constricted at the septum; wall chestnut or dark cinnamon-brown, paler over the pores, 2–3 μ, thickened apically to 6–13(–16) μ, usually in the form of a conspicuous papilla or beak, pore of upper cell apical or subapical, of lower next to the septum; pedicel yellowish or hyaline, thick-walled, persistent, 30–90 μ long, occasionally up to 125 μ in length.

HOSTS AND DISTRIBUTION: *Salvia glutinosa* L., Europe.

TYPE SPECIMEN: On *Salvia glutinosa*, Grintiesu-mare, Romania, Aug. 8, 1902, Constantineanu (Syd. Ured. *2234*) (Neotype).

ILLUSTRATIONS: Fischer, Uredineen der Schweiz, p. 328, Fig. 239b; FIG. 5 (from neotype).

Puccinia salviae resembles *P. glechomatis* DC. so closely that it has frequently been treated as a synonym of the latter. Saccardo (**5**) listed Unger's generic binomial and Cesati's specific binomial as synonyms of *P. glechomatis*. P. and H. Sydow (**6**) restored *P. salviae* to specific rank, citing the relatively distant relationships of the two hosts, differences in host habitat and differences in the sori as valid reasons for the separation of the rusts on *Salvia glutinosa* L. and *Glechoma hederacea* L.

FIG. 6. Teliospores of *Puccinia bithynica* (from type), × 800. 7. Teliospores of *P. bithynica* (from type), × 800. 8. Urediospore of *P. bithynica* (from Nattrass *820*), × 800.

Cruchet (**3**), using teliospores from *Glechoma hederacea*, inoculated both hosts and obtained infection only on *G. hederacea*. He presented the results of this test and of a morphological study as evidence in support of the separation established by Sydow. Further evidence in favor of the separation of *P. salviae* and *P. glechomatis* was obtained by Kuhnholtz-Lordat (**4**), who found distinct differences between the two species in the development of the sporogenous stroma in the telial sorus.

In the present study it has been found that the differences in teliospore morphology are not sufficient readily to differentiate the two species; however, in view of the evidence presented by Cruchet and Kuhnholtz-Lordat it appears advisable to maintain the separation of *P. salviae* and *P. glechomatis*.

6. PUCCINIA BITHYNICA Magn., Bull. Herb. Boiss. 2 ser. **1903**: 579. 1903.

Puccinia nevadensis Syd., Ann. Mycol. **14**: 256. 1916.
Puccinia salviae-interruptae Maire apud Maire & Werner, Mem. Soc. Sci. Nat. Maroc. **45**: 72. 1937.

Spermagonia, aecia and uredia unknown. Urediospores in the telia, globoid or occasionally broadly ellipsoid, 16–30 × 20–30 μ; wall yellowish, closely and finely punctate-verrucose, 1–2 μ thick, pores usually 6–8, occasionally 3–5, scattered, in sunken areas of the wall, each capped by a hyaline papilla. Telia amphigenous and caulicolous, round or elliptic, 0.2–1.5 mm in diameter, in groups up to 5 mm across on leaves and up to 17 mm long on stems, compact, pulvinate, chestnut-, chocolate- or blackish brown; teliospores variable, of two types: lepto-form and resting, lepto-form teliospores ellipsoid, clavate, fusiform or cylindrical, 16–33 × 33–70 μ, rounded or narrowed at both ends, slightly to sharply constricted at the septum; wall yellowish, cinnamon- or light chestnut-brown, frequently darker in the upper half, 2–3 μ, thickened to 4–7(–12) μ at the apex, smooth, pore of upper cell apical, of lower next to the septum; pedical yellowish or hyaline, thick-walled, persistent, up to 150 μ long. Resting teliospores ellipsoid, oblong, clavate or fusiform, 16–37 × 30–76 μ, rounded above, rounded or narrowed below, slightly constricted at the septum, wall cinnamon- to dark chestnut-brown, frequently darker in the upper half, 2–4 μ, thickened to 4–10(–14) μ at the apex, smooth, pore of upper cell apical, of lower next to the septum; pedicel yellowish or hyaline, thick-walled, persistent, up to 200 μ long. Mesospores common, globoid or ellipsoid, 16–36 × 21–58 μ, wall cinnamon- or chestnut-brown, 2–5 μ, thickened apically to 6–10(–13) μ, smooth, pore apical; pedicel yellowish or hyaline, thick-walled, persistent, up to 180 μ long.

HOSTS AND DISTRIBUTION: *Salvia acetabulosa* Vahl, *Salvia aucheri* Benth., *Salvia grandiflora* Ettl., *Salvia interrupta* Schausb., *Salvia lavandulaefolia* Vahl, *Salvia pomifera* L. and *Salvia rubifolia* Boiss.; southern Europe, North Africa and Asia Minor.

TYPE SPECIMEN: On *Salvia grandiflora* Ettl., Mt. Keschisch-dagh, Bithynia, Turkey, June 2, 1899, Bornmüller *2049*.

ILLUSTRATIONS: Magnus, Bull. Herb. Boiss., 2 ser., No. 7, **1903**, pl. IV, Figs. 14, 14a; Nattrass, A First List of Cyprus Fungi, p. 77, Fig. 2; FIGS. 6, 7 (from type), FIG. 8 (from Nattrass *820*).

The teliospores of *Puccinia bithynica* show extreme variation in size and shape; this variability is frequently evident even among the spores obtained from a single sorus. In the North African specimens there is a preponderance of thinner-walled teliospores which germinate without a resting period. On *Salvia aucheri* the teliospores are mostly fusiform or cylindrical.

The urediospores of *P. bithynica* are distinct from those of most other *Salvia* rusts in having scattered pores. In number and arrangement of pores and in wall characters the urediospores resemble those of *P. roesteliiformis* Lagerh., a South American *Salvia* rust.

IOWA STATE COLLEGE,
AMES, IOWA

LITERATURE CITED

1. **Baxter, J. W. and G. B. Cummins.** 1951. A monograph of species of *Puccinia* occurring on *Salvia* in North America. Lloydia **14**: 201–230.
2. ———. 1953. South American species of *Puccinia* on *Salvia*. Mycologia **45**: 115–135.
3. **Cruchet, P.** 1906. Contributions à l'étude biologique de quelques Puccinies sur Labiées. Centralbl. f. Bakt., Abt. II, **17**: 212–224.
4. **Kuhnholtz-Lordat, M. G.** 1943. Essai de biologie des spores du diplonte chez les Uredinées. Bull. Soc. Myc. Fr. **59**: 78–156.
5. **Saccardo, P. A.** 1888. Sylloge Fungorum **7**: 882 pp. Padova.
6. **Sydow, P. and H.** 1904. Monographia Uredinearum **1**: 972 pp. Borntraeger, Leipzig.

A NEW SPECIES OF PENICILLIUM FROM SOIL

PHILIP A. ORPURT[1] AND DOROTHY I. FENNELL[2]

(WITH 5 FIGURES)

A striking and apparently previously undescribed species of *Penicillium* has been isolated repeatedly during an ecological study of the microfungi in Wisconsin prairie soils. Nine strains of the fungus were isolated from soils collected from a depth of one inch at five stations in southern Wisconsin between May 1952 and May 1953. A representative of this same species was submitted to the Culture Collection of the Northern Utilization Research Branch for identification in 1950 by Dr. J. H. Warcup, Cambridge, England. He had isolated it in 1947 from soil collected in Lakenheath Warren, Suffolk. Warcup, noted, in correspondence relative to the culture, that the fungus was quite common in soils there.

A careful review of presently recognized species of *Penicillium* clearly indicates that the cultures isolated first in England, and subsequently in Wisconsin, represent a new species in the genus. These cultures in question have been examined by Prof. Kenneth B. Raper who concurs in this opinion. A description of the fungus follows.

Penicillium megasporum sp. nov.

Coloniae in agaro Czapeki satis rapide crescentes, post hebdomades duas 4.0–4.5 cm attingentes, mycelio tenui denso compositae, coactum fere fragilem efformantes, radiatim rugosae, area centrali saepe elevata et fructificationes conidicas limitatas gignenti, olivaceo-bubalinae usque olivascentes, zona 2.0–3.0 mm lata circumdatae, deinde a fructificationibus conidicis viridi-atrae, in aream albam submarginalem exeuntes, exsudato carentes; odor non distinctus; reversum post dies 10 olivaceo-ochraceum usque flavo-olivaceum, in actate brunneum, pigmento in medium diffluenti; conidiophora e substrato vel coacto aerio oriunda, septata, glabra, hyalina, 3.0–4.0 μ diam., usque 300 μ alta; penicilli biverticillati, asymmetricales, divaricati, variabiles sed plerumques verticillio metularum 2–6 divergentium compositi; metulae plerumque 4.0–5.0 × 10–12 μ; sterigmata 3–5 in metula quaque, divergentia, lageniformia, 5.0–7.0 × 3.0–4.0 μ; conidia in catenulis brevibus divergentibus disposita, sphaerica, plerumque 6.5 μ in diam. (5.0–7.0 μ), crassitunicata,

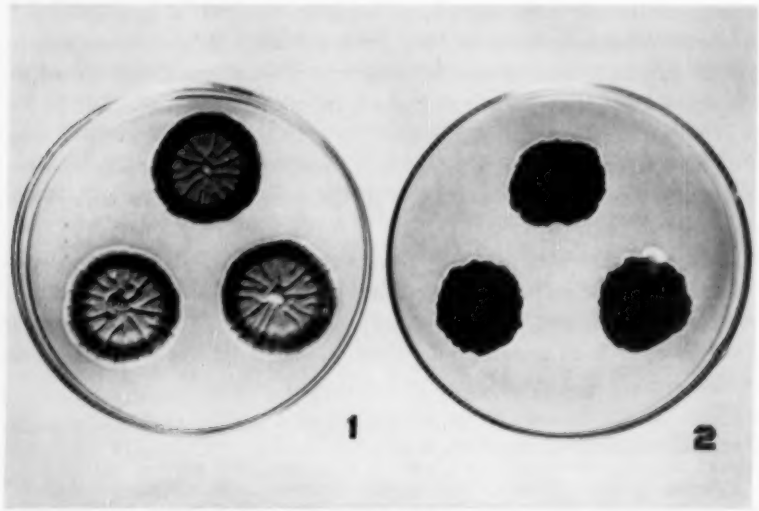
[1] Present address, Manchester College, North Manchester, Indiana.

[2] Present address, Pioneering Research Div., QM R. & D. Center, Natick, Massachusetts.

in aetate obscura olivaceo-brunnea, crasse echinulata, spinis obscuris 1.0–1.5 μ longis; disjunctores prominetes, 1.0–2.0 μ longis, 1.0–1.5 μ latis.

E solo isolatum, Wisconsin et Anglia.

Colonies on Czapek's solution agar (FIG. 1) growing fairly rapidly, attaining a diameter of 4.0–4.5 cm in two weeks at room temperature; consisting of a thin, close-textured mycelium, forming an almost brittle felt; radially furrowed, central area often raised and bearing limited conidial structures, becoming olive-buff to deep olive (Ridgway, Pl. XLV); surrounded by a zone 2.0–3.0 mm wide, becoming dull greenish black (R., Pl. XLVII) due to presence of abundant conidial structures, shading into a white submarginal area; exudate lacking; odor not dis-

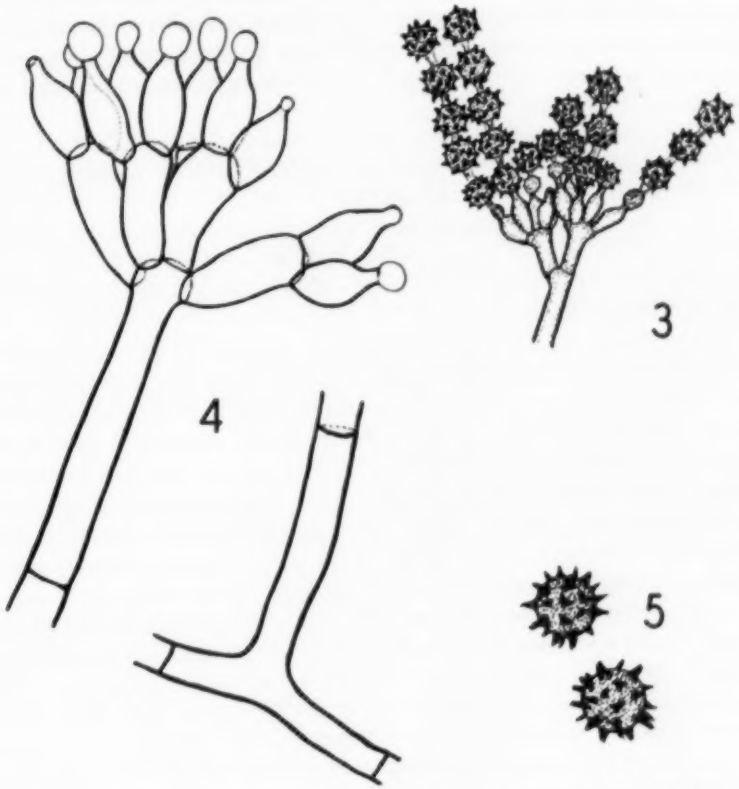


FIGS. 1, 2. 1. *Penicillium megasporum*, NRRL *2232*, on Czapek's solution agar, 10 days, room temperature. 2. Same, on malt extract agar.

tinctive; reverse olive-ochre to yellow-olive at 10 days, near Prout's brown (R., Pl. XV) in age, with the pigment diffusing into the agar; conidiophores arising from the substrate or the aerial felt, septate, smooth, hyaline, 3.0–4.0 μ in diameter and up to 300 μ in height; penicillia (FIGS. 3, 4) biverticillate, asymmetric, divaricate, variable in pattern but usually consisting of a verticil of 2–6 divaricate metulae; metulae mostly 4.0–5.0 × 10–12 μ; sterigmata 3–5 per metula, divergent, bottle-shaped, 5.0–7.0 × 3.0–4.0 μ; conidia in short divergent chains, spherical, averaging 6.5 μ in diameter (5.0–7.0 μ), thick-walled, dark olive-brown at maturity, coarsely echinulate, with dark-colored spines 1.0–1.5 μ in

length (FIG. 5); prominent disjunctors 1.0–2.0 μ long by 1.0–1.5 μ wide.

Colonies on steep agar essentially as above in rate of growth, texture, and colony pattern, but somewhat less regularly furrowed and slightly raised; conidial structures produced somewhat more abundantly with colonies more quickly assuming dull greenish-black shades and



FIGS. 3–5. 3. Camera lucida drawing showing a characteristic penicillus of *P. megasporum* and the extremely echinulate conidia with prominent disjunctors, × 525. 4. Details of fruiting structure of *P. megasporum*, × 1050. 5. Conidia of *P. megasporum* showing the characteristic echinulations, × 1050.

becoming olive-brown in age; exudate lacking; reverse and agar pigmented as on Czapek's; penicilli generally more regular in pattern.

Colonies on malt extract agar (FIG. 2) growing more slowly, attaining a diameter of 3.5–4.0 cm in 10 days, flat, unfurrowed, vegetative

mycelium submerged, not forming a brittle felt, heavily sporulating, abundantly velvety but showing a thin surface network of aerial hyphae bearing scattered conidial structures, with thin marginal area white, shading rapidly through shades of American green to dull blackish green (R., Pl. XL), finally becoming olivaceous black (R., Pl. XLVII); no exudate; reverse uncolored or nearly so; penicilli generally as described above but occasionally showing much more complex structures re-branched as many as five or six times below the level of the sterigmata, consistently producing the coarsely echinulate, spherical conidia characteristic of the species.

The proposed species name, *megasporum,* is based upon the Greek word μέγας (large) and has been selected because of the unusually large conidia which characterize the species.

The species description is based upon the following *syntypes:* Wis. No. S *281–2* isolated from prairie soil in southern Wisconsin, and NRRL *2232* received from Dr. J. H. Warcup as an isolate from heath soil in Suffolk, England.

Penicillium megasporum can be best assigned to the *P. nigricans* series in the Asymmetricia-Divaricata section of the genus as considered by Raper and Thom (**1949**). It would seem to be more closely related to *P. melinii* Thom than to any other presently recognized species, although it differs from the latter species in certain striking characteristics. The globose, rough conidia of *P. megasporum* average about 6.5 μ in diameter, whereas those of *P. melinii* measure 3.0–3.5 μ; and the conidiophores of *P. megasporum* are smooth on all substrata while those of *P. melinii* are conspicuously granular-tuberculate.

The penicilli of the syntypes and similar strains are comparatively short, broad and conspicuously divaricate. Typically, they consist of a single verticil of metulae, each bearing a cluster of sterigmata. Not uncommonly, however, penicilli on Czapek's solution agar vary somewhat from this pattern, and on malt agar conidial structures are sometimes seen which are re-branched several times (5–6) below the level of the sterigmata.

Of the nine strains isolated from Wisconsin soil, 8 duplicate the pattern presented by the sy..cype, Wis. S *281–2.* One isolate, Wis. *349–3,* differs from these strains in developing more slowly-growing, deeper, almost flocculent colonies; in producing more variable and often fractional or malformed penicilli; and, in bearing "warty" rather than coarsely echinulate conidia.

The nine isolates from Wisconsin soil were all obtained from grasslands characterized ecologically as mesic or high prairies (Curtis, in

press). Warcup's isolation was made from heath soil (Warcup, **1951**), and he stated in correspondence that they were fairly common in such soils. The culture submitted to the Northern Laboratory for identification is cited in his paper "The Ecology of Soil Fungi" (**1951**) as Strain No. B *13*. To date the species herein described has been isolated only from grassland soils. We have insufficient evidence to conclude that it is limited to this habitat; however, it seems possible that it may represent a characteristic member of the mycoflora of such ecological communities.

SUMMARY

A new species of *Penicillium, P. megasporum,* has been isolated from grassland soil in southern Wisconsin and from heath soil in Suffolk, England.

The species, characterized by unusually large, coarsely echinulate conidia averaging 6.5 μ in diameter, produces divaricate penicilli and is assigned to the *P. nigricans* series of the section Asymmetrica-Divaricata.

The new species is considered to represent a possible normal component of the mycoflora of grassland soils.

ACKNOWLEDGMENT

The authors wish to express their appreciation to Miss Edith K. Cash, Bureau of Plant Industry, Beltsville, Maryland, for preparing the Latin diagnosis; to Mr. Eugene Herrling, Department of Plant Pathology, University of Wisconsin, for making the photographs; and to Professor Myron P. Backus, Botany Department, University of Wisconsin, for his encouragement throughout the work.

UNIVERSITY OF WISCONSIN,
MADISON, WISCONSIN
AND
NORTHERN UTILIZATION RESEARCH BRANCH, U.S.D.A.,
PEORIA, ILLINOIS

LITERATURE CITED

1. **Curtis, J. T.** A prairie continuum in Wisconsin Ecology (in press).
2. **Raper, K. B. and C. Thom.** 1949. A Manual of the Penicillia. 875 pp. Williams & Wilkins Co., Baltimore, Md.
3. **Ridgeway, R.** 1912. Color Standards and Color Nomenclature. Publ. by the author. Wash., D. C.
4. **Warcup, J. H.** 1951. The ecology of soil fungi. Trans. Brit. Mycol. Soc. **34**: 376–399.

A RECLASSIFICATION OF THE GENUS PERICYSTIS BETTS

CHARLES F. SPILTOIR[1] AND L. S. OLIVE

(WITH 2 FIGURES)

In the course of recent studies on the life history and cytology of *Pericystis apis*, a detailed account of which will be published in the near future by one of the authors (C. F. S.), it was discovered that the genus has been erroneously classified by most authors among the Hemiascomycetes. The genus is often cited as a very primitive transitional group showing phylogenetic relationships with the Oomycetes. Claussen (**1921**), after considering the possible relationships of the group with the ascomycetes on one hand and the Entomophthoraceae and Mucoraceae on the other, finally concluded that it could not be placed in any of these groups and that it has no near relatives.

The genus *Pericystis*, as described by Betts (**1912**), was designed to accommodate the species *P. alvei*, which was reported by her to be a common fungus in England on pollen in beehives. Betts did not speculate on the taxonomic position of the genus, and apparently no one has studied the species in any detail since. Shortly after Betts' description, Maassen (**1916**) published an article on bee diseases in which he referred to "chalk brood," a well-known disease in central Europe affecting the larvae of honey-bees. In this paper, Maassen named the fungus *P. apis* and pointed out that it is different from *P. alvei*, but he gave no description of it at this time and made no reference to his earlier description of it in 1913.

It was Claussen (**1921**) who gave the first detailed description of *P. apis*, following Maassen's naming of it. Claussen was also the first to make an extensive study of the life cycle of this species. He described male and female mycelia, the former producing "antheridia" and the latter producing "oogonia" when the cultures are paired. He further stated that the "antheridium" empties its contents into the enlarging "oogonium," after which there are delimited within the latter balls of protoplasm in which the spores are cut out. Varitchak (**1932**, **1933**) was the first to study the fungus cytologically. He found that the sex

[1] Present address: Department of Biology, University of Bridgeport, Bridgeport, Connecticut.

organs are multinucleate and that the "antheridium" sends into the "oogonium" a "fertilization tube." He claimed that the contents of the "fertilization tube" discharge into the "oogonium" and that there is a pairing of male and female nuclea followed by karyogamy. A dense mass of protoplasm reportedly is delimited about each fusion nucleus to form an "egg." In each "egg" a series of nuclear divisions, including meiosis, occurs and uninucleate spores are cut out, thus resulting in the formation of spore balls. Each spore ball was considered by Varitchak the equivalent of an ascus and each mature cyst (mature "oogonium") of spore balls was called a "synascus." Varitchak described a new family—the Synascomycetaceae—to accommodate the genus *Pericystis*. In the light of our investigations, we find the name to be a misleading one. Fortunately, since the family name fails to be derived from a generic name it is not legitimate, and therefore we do not recognize it as a valid name here.

Maurizio (**1934**, **1935**) reported finding a larger-spored form of *P. apis* in addition to the typical form described by previous investigators. The two forms were not only found to differ in their microdimensions, but they also failed to cross with one another. Maurizio considered the possibility that the larger-spored form might be a different species but did not describe it as such. Prökschl (**1953**) also studied these two forms and considered the possibility of treating the larger-spored form as a separate species. However, he compromised by recognizing the two as different varieties of the same species. Prökschl's cytological findings and his interpretation of the life cycle of *P. apis* are essentially in agreement with the findings of Claussen and Varitchak.

In his recent text, Bessey (**1950**) recognized *Pericystis* as a genus of "doubtful kinship," but placed it among the Hemiascomycetes in the family Pericystaceae. There is no valid description of the latter as a new family in Bessey's text, and we have been unable to find any prior reference to it elsewhere. Therefore, we can only assume that it is not a validly publishd name.

In our own studies of *P. apis*, we have found certain important developments quite different from those reported by previous investigators. We find that there are indeed two types of mycelia, which may be called male and female. The fungus is a genetically dimorphic species (morphologically heterothallic), as demonstrated by Claussen's discovery that the spores from the spore balls give rise to male and female mycelia in a 1 : 1 ratio. It should be noted that there are no important morphological differences between the two types of mycelia when they are maintained separately, and no sex organs are produced under these

circumstances. But when the cultures are paired, the female mycelium produces ascogonia, while the male produces no sex organs at all. The ascogonium is comprised of what we shall call a trichogyne, a *nutriocyte*, and a stalk-like base continuous with the parent hypha. As the name suggests, the nutriocyte later performs the function of nourishing the developing ascogenous system. The trichogyne fuses with the male hypha, a receptive papillum often appearing on the latter at the point of contact (FIG. 1).

The trichogyne is the structure referred to by Claussen (**1921**), Varitchak (**1933**), and others as the antheridium. Betts (**1912**), in her

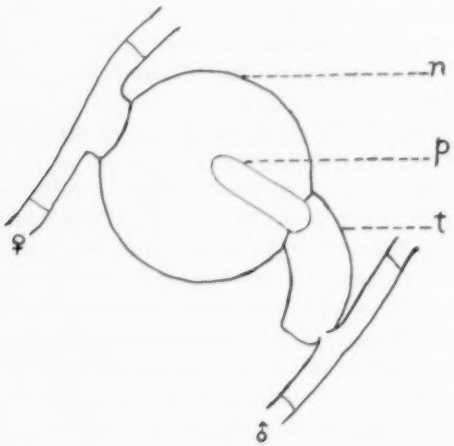


FIG. 1. *Ascosphaera apis*. Ascogonium following plasmogamy, showing nutriocyte (n), primary ascogenous hypha (p), and trichogyne (t).

studies of *P. alvei*, is probably the only previous investigator to note that the trichogynes, which she identified only as "processes," fuse with neighboring hyphae.

Following plasmogamy in *P. apis*, a cylindrical mass of protoplasm—the primary ascogenous hypha—passes from the trichogyne into the nutriocyte where it develops a thin wall around itself and proliferates to produce an ascogenous system of croziers and asci. The asci become aggregated into balls, each ascus apparently producing 8 ascospores, and in this manner the spore balls are formed (FIG 2). The much enlarged nutriocyte is at this time nearly devoid of protoplasm and is now referred to as the spore cyst, in accordance with the terminology of several previous investigators.

It is obvious that the terminal cell of the ascogonium functions not only as a trichogyne but also as the female gametangium. However, it seems probable that the specialized type of ascogonium found in *Pericystis* has evolved from a less specialized type such as is found in the genus *Monascus* of the Plectascales. Although *Monascus* is not known to contain any heterothallic species, the early stages of sexual reproduction in this group are strikingly similar to the early stages in *Pericystis*. Also, in view of the fact that the crozier system is in many respects similar to that described for *Aspergillus* (Olive, **1944**), the writers be-

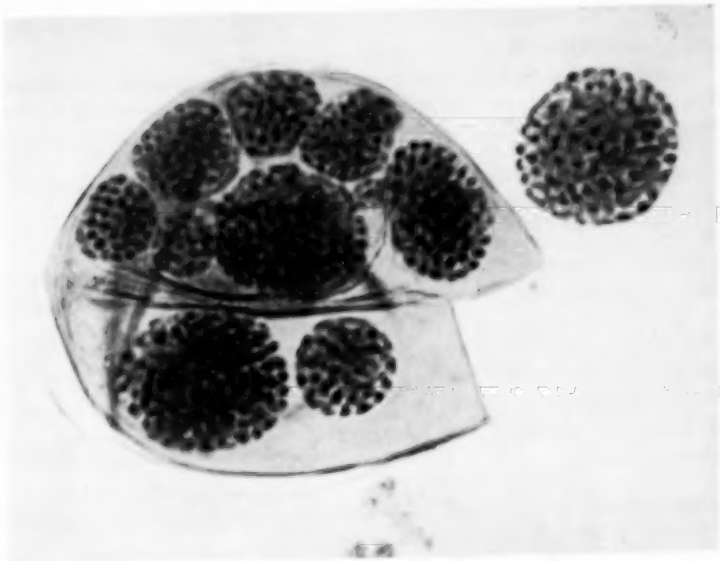


FIG. 2. *Ascosphaera apis*. Mature spore cyst (broken) containing a number of spore balls. × 1250.

lieve that *Pericystis* should be placed in the Plectascales, though not in any existing family in that order.

Recently, it was brought to our attention by Dr. D. P. Rogers that the name *Pericystis* Betts is predated by *Pericystis* Agardh (Öfv. K. Vet.-Akad. Forh. 4: 6. [1847] 1848), a validly published name for a genus of red algae. The name *Pericystis* may therefore no longer be accepted as applicable to a genus of fungi. For this reason the present writers propose a new generic name as a substitute for *Pericystic* Betts. Also, in view of the fact that *P. apis* is much better known than *P. alvei*,

and since we have been unable to obtain fertile cultures of *P. alvei* for study, we believe that it is desirable to designate *P. apis* as the type species of the new genus. The following taxonomic treatment is in accord with the foregoing discussion.

Ascosphaeraceae Olive & Spiltoir, fam. nov.

Mycelium ramosum, septatum. Asci intra ascogonii cellulam inflatum in sphaerulis compactis glomerati, e hyphis ascogenis hamatis producti.

Mycelium branched, septate. Asci produced in compact balls within an enlarged cell of the ascogonium, arising from an ascogenous system with croziers.

Ascosphaera Olive & Spiltoir, gen. nov.

Fungus de sexu biformis. Thallus masculus papillas receptorias producens, femina ascogonia, filamento receptorio atque cellula nutritoria instructa. Hypha ascogena primaria, nucleis et masculis et feminis inclusis, post plasmatum mixturam e filamento receptorio in cellulam nutritoriam penetrans, systema ascogenum hamatum gignens. Asci probabiliter 8-spori, plures in sphaerulis sporarum compactis glomerati. Ascosporae parvae, hyalinae, laeves.

Typus: *Pericystis apis* Maassen ex Claussen.

Sexually dimorphic fungi [2] with septate mycelia, the male producing receptive papillae but no sex organs, the female producing ascogonia, each with trichogyne (or trichogynes) and nutriocyte. Primary ascogenous hypha, containing male and female nuclei following plasmogamy, passing from trichogyne into nutriocyte and proliferating there to produce an ascogenous system with croziers. Asci probably 8-spored, united several to many into compact spore balls. Ascospores small, hyaline, smooth.

Ascosphaera apis (Maassen ex Claussen) Olive & Spiltoir, comb. nov.

Pericystis apis Maassen ex Claussen

Mycelium without chlamydospores. Ascogonium with single trichogyne, a nutriocyte, and a stalk-like base continuous with the supporting hypha. Asci produced by crozier proliferation within the nutriocyte, apparently 8-spored at maturity, uniting into compact masses which appear as spore balls; ascospores minute, ellipsoidal, measuring 1.5–2.3 × 3–3.8 μ, or slightly larger in one variety. Parasitic on larvae of honey bees.

Two varieties are recognized, and these are distinguished primarily on differences in size of the mature nutriocytes or spore cysts and the

[2] Judging from the illustrations of *A. alvei* by Betts, we are assuming that it, like *A. apis*, is also morphologically heterothallic. Conclusive evidence of this must come from future investigation.

inability of the two forms to cross. It has been suggested that the two forms may be different species (Maurizio, **1935**; Prökschl, **1953**). However, they have thus far been treated only as varieties of the same species and will be so treated here, pending further studies by future investigators.

Ascosphaera apis var. **apis** (Type var.)

Pericystis apis Maassen ex Claussen

Pericystis apis var. *minor* Prökschl & Zobl.

Spore cysts typically 32–99 μ in diam., averaging about 65.8 μ; ascospores about 1.5–2.3 × 3–3.8 μ.

Ascosphaera apis var. **major** (Prökschl & Zobl) Olive & Spiltoir

Pericystis apis var. *major* Prökschl & Zobl

Spore cysts typically 88.4–168.5 μ in diam., averaging about 128.4 μ; ascospores about 10 per cent larger than in the type variety.

The above descriptions of *Ascosphaera apis* and its varieties are composite descriptions based on information from the publications of Claussen (**1921**), Maurizio (**1935**), Prökschl (**1953**) and upon our own observations. We have not examined *A. apis* var. *major*.

Although we have obtained cultures of *A. alvei* for examination, they were not fertile, and the following description is based upon the original description by Betts (**1912**).

Ascosphaera alvei (Betts) Olive & Spiltoir

Pericystis alvei Betts

Hyphae 2–6 μ diam.; chlamydospores present, 4.5–7 × 4.5–9.5 μ; ascogonium with one or two (rarely three) trichogynes; spore cysts 20–30 × 20–40 μ; ascospores spherical, 3.7–4.7 μ diam. On pollen in the combs of the honey-bee.

As far as the writers are able to determine, *Ascosphaera* occurs primarily in Europe and England, and neither species has been reported to occur in the western hemisphere.

The writers are very grateful to Dr. D. P. Rogers for his assistance with nomenclatural problems and for his preparation of the Latin descriptions.

DEPARTMENT OF BOTANY
COLUMBIA UNIVERSITY
NEW YORK 27, N. Y.

LITERATURE CITED

Bessey, E. A. 1950. Morphology and Taxonomy of Fungi. Blakiston.

Betts, Annie D. 1912. A bee-hive fungus, *Pericystis alvei*, gen. et sp. nov. Ann. Bot. **26**: 795–799.

Claussen, P. 1921. Entwicklungsgeschichtliche Untersuchungen über den Erreger der als Kalkbrut bezeichneten Krankheit der Bienen. Arb. Biol. Reichsanst. f. Land- u. Fortsw. **10**: 467–521.

Maassen, A. 1913. Weitere Mitteilungen über die seuchenhaften Brutkrankheiten der Bienen, insbesondere über die Faulbrut. Mitt. k. Biol. Anst. Land.- Fortsw. **14**: 48–58.

——. 1916. Über Bienenkrankheiten. Mitt. k. Biol. Anst. Land.- Fortsw. **16**: 51–58.

Maurizio, Anna. 1934. Über die Kalkbrut (Pericystis-Mykose) der Bienen. Arch. f. Bienenkunde **15**: 165–193.

——. 1935. Beiträge zur Kenntnis der Pilzflora im Bienenstock. I. Die Pericystis-Infektion der Bienenlarven. Ber. Schweiz. Bot. Ges. **44**: 133–156.

Olive, L. S. 1944. Development of the perithecium in *Aspergillus Fischeri* Wehmer, with a description of crozier formation. Mycologia **36**: 266–275.

Prökschl, H. 1953. Beiträge zur Kenntnis der Entwicklungsgeschichte von *Pericystis apis* Maassen. Arch. f. Mikrobiol. **18**: 198–209.

Varitchak, B. 1932. L'évolution nucléaire chez le *Pericystis apis* Maassen. Compt. Rend. Acad. Sci. [Paris] **194**: 300–302.

——. 1933. Deuxième contribution à l'étude du développement des Ascomycètes. L'évolution nucléaire dans le sac sporifère de *Pericystis apis* Maassen et sa signification pour la phylogénie des Ascomycètes. Le Botaniste **25**: 343–391.

A NEW SPECIES OF STYLOPAGE CAPTURING NEMATODES

C. L. Duddington

(with 1 figure)

This fungus was found in rotting vegetable matter from the floor of Ashtead Wood, near Leatherhead, Surrey, England. Small portions of the material sown on plates of sterile maize-meal agar gave rise to a mixed culture of moulds, amoebae and other microscopic animals in which nematode worms were plentiful, and about a month after inoculation nematodes of various species were being preyed upon by a fungus with a mycelium of sparingly branched, non-septate hyphae about 5 μ wide. The eelworms were attached to the hyphae by means of a sticky secretion which could be clearly seen under the microscope as the animals struggled in vain to free themselves; this adhesive material was colourless, and appeared to be of about the viscosity of treacle. It was secreted copiously by the mycelium at the point where the eelworm was held, and it appeared to be produced only on contact with the prey, as no trace of it could be seen on other parts of the mycelium.

After a period of violent struggling the captured eelworm finally became quiescent and, apparently, moribund. An outgrowth from the fungus at the point of contact then penetrated the integument of the nematode and from this penetration branch a system of non-septate trophic hyphae grew out, eventually filling the carcass of the eelworm and absorbing its contents (Fig. 1*a*, *b*). The trophic hyphae were a little smaller in diameter than the filaments of the main mycelium.

Conidia were produced abundantly after an initial period of feeding. The fertile hyphae were long, rising slender and erect to a height of 300–500 μ, and each bore at its apex a large conidium. Sometimes a second spore was formed after further elongation of the conidiophore (Fig. 1*c*). The conidia were obovoid or pyriform, (22–)27–61 μ long and 13–26 μ across their greatest diameter (Fig. 1*d*). In spite of their great size they were produced in abundance.

No sexual reproduction took place, although the cultures were kept under observation for several months. Attempts to isolate the fungus by picking off conidia and placing them aseptically on sterile maize-meal agar and sterile rabbit dung agar failed, as the spores did not germinate. This is in accordance with experience, for I have on former occasions

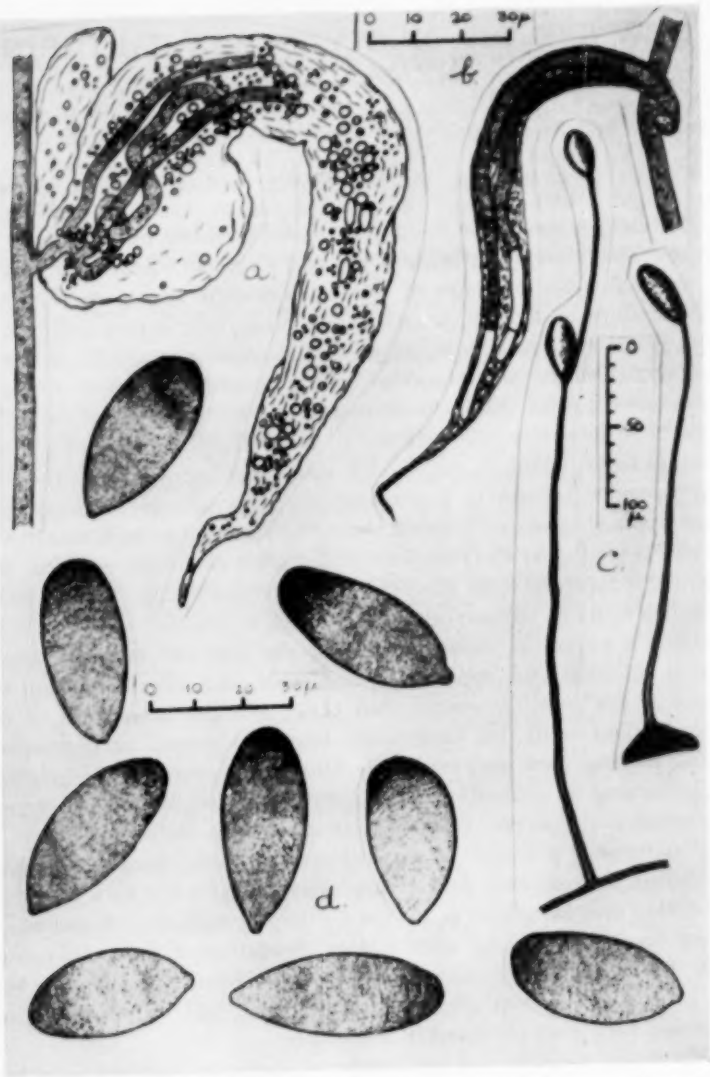


FIG. 1. *Stylopage grandis*. *a*, *b*. Part of mycelium with captured eelworms, showing origin of trophic hyphae. *c*. Two fertile hyphae, one with a second conidium. *d*. Conidia.

attempted to isolate *Stylopage hadra* Drechsler and *S. rhynchospora* Drechsler by the same method and have always failed to persuade the spores to germinate, although they were germinating freely on plates contaminated with nematodes, amoebae and other fungi. Like other Zoopagaceae, the fungus here described appears to be an obligate predator.

The very large conidia of this fungus set it apart from all other species in the Zoopagaceae. *S. hadra* Drechsler (**1**) comes nearest, with conidia measuring 20–43 × 13–23 μ, but even these are smaller than those of the fungus under discussion. *S. hadra*, moreover, forms a prominent bulbous appressorium before invading its prey by trophic hyphae; this structure is a conspicuous feature in the drawings given by Drechsler (**1**) and was clearly present in the specimens that I have seen in Britain (**3**, **4**), but was absent from the Ashtead fungus. *S. leiohypha* Drechsler (**2**) also captures eelworms and lacks the appressorium, but its spores are smaller. It seems necessary, therefore, to erect *Stylopage grandis* as a new species of the Zoopagaceae, the epithet being chosen on account of the great size of its conidia and the impressive appearance of its lofty fertile hyphae.

Stylopage grandis sp. nov.

Hyphae continuae, hyalinae, ca. 5 μ crassae, vermiculis nematodeis adhaerentes et substantiam corporis hyphis edentibus ca. 4 μ crassis absorbentes. Hyphae fertiles erectae, plerumque 300–500 μ longae, singulae unum conidium aut, semper crescentes, secundum conidium ferentes. Conidia hyalina, non septata, obovata aut pyriformia, (22–)27–61 μ longa, 13–26 μ crassa. Zygospora ignota.

Capiens vermiculos nematodeos diversos hab. plantas putridas in Ashtead Wood, Surrey, England, April 1952. Duddington *148* typus.

The type specimen of *Stylopage grandis* is in the author's herbarium. Material from the type collection will be deposited in the Herbarium of the Royal Botanic Gardens, Kew, and in the Herbarium of the Commonwealth Mycological Institute, Kew.

All drawings and measurements used in this communication were made from living material.

I should like to thank Mr. J. A. Easterling for his kindness in preparing the Latin diagnosis. The work described here was assisted by a grant from the Agricultural Research Council, to whom my thanks are also due.

BIOLOGICAL LABORATORIES,
THE POLYTECHNIC,
REGENT STREET,
LONDON, ENGLAND

LITERATURE CITED

1. **Drechsler, C.** A new species of conidial Phycomycete. Mycologia **27**: 206–215. 1935.
2. ——. A new species of *Stylopage* preying on nematodes. Mycologia **28**: 241–246. 1936.
3. **Duddington, C. L.** Predacious fungi from Cotswold leaf-mould. Nature, Lond. **145**: 150–151. 1940.
4. ——. Predacious fungi. Jour. Quekett micr. Cl. Ser. 4, **3**: 67–88. 1950.

SOME LEAFSPOT FUNGI ON WESTERN GRAMINEAE—VIII [1]

RODERICK SPRAGUE

(WITH 1 FIGURE)

This is the second article on fungi found on Alaskan grasses which were collected during the course of seven weeks' field work in recently deglaciated territory in southeastern Alaska (**18**). This paper completes the strictly taxonomic study of these 1952 gramineous collections.[2]

Leptosphaeria muirensis sp. nov.

Maculis foliicolis, orbiculatis v. ellipticis, centro pallidis; margine brunneis, non gregariis, parvis, 0.8–1.8 mm diam., peritheciis 1–2 per maculam, globosis, parenchymaticis, brunneis, ostiolatis, 90–150 μ; ascis subcylindraceis, 45–60 × 13–15 μ, sporulis 3-septatis, sub-cultiformibus, chlorinis, 20–22× 6 μ.

Leafspots round, less often elliptical, pale buff to straw color with definite brown border, scattered, small, 0.8–1.2 mm diam., perithecia 1–2 per leaf or absent, globose, parenchymatous, brown, ostiolate, 90–150 μ; asci subcylindrical or thickly clavate, 45–60 × 13–15 μ; ascospores 3-septate, sub-cultiform, flattened on one side, yellow to yellow-brown, 17–22 × 5–6.5 μ.

On living leaves of *Poa annua* in a sheltered, shallow depression on rocky Muir Island, Glacier Bay National Monument, A.S. *33,757* [3] (type), August 11, 1952 and also found on the seashore at Auk Village Recreation Area, A.S. *33,780* (paratype), July 16, 1952.

[1] Scientific Paper No. *1305*, Washington Agricultural Experiment Stations, Pullman.

[2] Financed in part by the U. S. Office of Naval Research and the American Geographical Society. Organized by Donald B. Lawrence, University of Minnesota, with additional personnel loaned by the State College of Washington and University of California.

The writer again thanks Donald Lawrence, Elizabeth Lawrence, Robert Crocker and Roland Schoenike for their splendid help during the summer of 1952. He appreciates the aid of the Juneau Botanical Society for their friendly gesture in permitting removal of certain leafspot material from the mounted sheets in their considerable herbarium.

[3] A.S. refers to the Accession Series, Department of Plant Pathology, Washington State College. Since completion of this paper, the reference has been changed to WSP.

The fungus in the type and the paratype appears to be parasitic on living tissue. The grass in the type area was growing lushly in a pocket of sand and gull droppings but was exposed to the almost constant, glacier-chilled winds sweeping from Muir Glacier and the surrounding snow-covered mountains. This probably accounts for the development of ascigerous material in current-season host tissue. Its formation is comparable to that of *Mycosphaerella deschampsiae* Sprague (**18**). The cool, to sometimes chill, summer weather of coastal southeastern Alaska appears to favor the growth of the perithecial stage of many ascomycetes, frequently to the partial suppression of the asexual forms.

This species should eventually be cultured to determine if it develops conidia. While it may be the perithecial stage of a well-known fungus, it certainly cannot be so assigned on the basis of present knowledge. Its parasitic nature excludes it from any of the common 3-septate saprophytic species of *Leptosphaeria* which usually have much larger perithecia than *L. muirensis*.

The type locality, Muir Island, is a small rocky remnant rising some 30 feet above the waters of Muir Inlet. It was under ice at the time of Muir's visits to the region. Probably the host and also the fungus was brought by gulls, which swarm over the place.

MYCOSPHAERELLA DESCHAMPSIAE, described in the last paper in this series (**18**), was again noted on *Deschampsia atropurpurea* (Wahl) Scheele, this time from the slopes of Red Mountain, Glacier Bay National Monument. In this material the sub-circular spots were dark brown and surrounded by a relatively prominent halo of yellow. The small and somewhat immature perithecia were closely packed in the brown portion of some of the spots. I have seen what was probably this same fungus in other places in southeastern Alaska. Except for these two collections, however, the other specimens were sterile or contained young perithecia, and determination was uncertain. The fungus is probably not uncommon in the region. It should be mentioned, in passing, that among associated saprophytes on dead leaves of *D. atropurpurea* from Red Mountain a number of perithecia of *Microthyrium culmigenum* Sydow were seen.

SEPTORIA OUDEMANSII Sacc. caused purplish spots on leaves and sheaths of *Poa interior* Rydb. on Red Mountain. The material on this newly reported host is puzzling. The spores measure 20–35 × 1.7–3.2 μ and are therefore larger than in most collections of this fungus. They are more bacillar-shaped than *S. nodorum* Berk. and possibly too small for *S. avenae*. Because *S. oudemansii* sometimes produces spores much

larger than the average ones produced by this species, it is considered conservative to place this strain in *S. oudemansii* (A.S. *33,604*).

Typical *S. oudemansii* was collected on *Poa* growing in mixed woods at Tlingit Point, Glacier Bay National Monument (A.S. *33,753*). The host appears to be shade-inhibited material of *Poa compressa* L. *S. oudemansii* was also found on *Poa pratensis* L. nearby on Sebree Island with spores up to 22 μ long (A.S. *37,014*).

SEPTORIA CALAMAGROSTIDIS (Lib.) Sacc., which is common in Alaska, was found on another host, *Agrostis aequivalvis* Trin. on the banks of the Mendenhall River in an overflow area below Mendenhall Glacier (A.S. *33,612*). The spores were unusually strongly curved, almost touching terminals in some cases, 35–49 × 1.0–1.3 μ. The same fungus, but a different race, was noted on *Trisetum spicatum* (L.) Richt. on Red Mountain (A.S. *33,653*). The spores were stiff and less curved than those on *Agrostis* and measured 36–49 × 1.5–1.8 μ. *S. calamagrostidis* is common on this host in the western mountains (**14**). This report extends its geographical range north about one thousand miles. *S. calamagrostidis* was found on *T. cernuum* near Yankee Basin (A.S. *37,059*). The filiform, stiff spores were 25–45 × 1.1–1.5 μ. Tiny microspores were also present.

SEPTORIA TENELLA Cooke & Ellis was collected on the proliferated phase of *Festuca rubra* L. (*F. rubra* var. *prolifera* Piper) along the creek at Tlingit Point, Glacier Bay National Monument (A.S. *33,762*). Most of the material was microsporous. Proliferation in grasses in the humid and cool coastal portions of Alaska is common, especially in *Poa* spp. The condition does not appear to be associated with any specific insect or fungus. It is questioned whether such proliferated specimens actually warrant a taxonomic trinomial. For instance, we have some fragmentary material of *Spermospora subulata* (Sprague) Sprague on a proliferated phase of *Festuca ovina* var. *brachyphylla* (Schult.) Piper from the Mendenhall Glacier area (A.S. *33,763*). The proliferated host material would require a quadrinomial, *F. ovina* var. *brachyphylla* forma *prolifera!* These proliferated specimens do not appear to represent any genetic change, nor do they appear to have any means of reproducing themselves.

Some years ago Saccardo, Peck and Trelease (**8**) reported *S. grylii* on *Agrostis exarata* with spores 75–90 × 1–2 μ. I suggested that these were probably *S. calamagrostidis* (**13**). Anderson reported *S. graminicum* on *A. exarata* from Alaska also (**2**). Cash has retained these names in her Alaska check list (**4**) but refers to my comments as indicating they probably belonged in *S. calamagrostidis*. We have

authentic material of *S. calamagrostidis* on *Agrostis exarata* collected at Beartrack Cove, Glacier Bay National Monument (A.S. *37,090*) with spores 45–75 × 1.0–1.4 μ. I see no reason why *S. gramineum* and *S. grylii* cannot be deleted from the Alaskan list. Fischer and I include *S. calamagrostidis* on *A. exarata* in our western grass disease check list (**19**) and my recent collection from Beartrack Cove is not new to the territory. The fungus is probably common on this host in the area.

ASCOCHYTA SORGHI Sacc. occurs on necrotic leaves of *Agrostis scabra* var. *geminata* (Trin.) Swallen on Red Mountain, Glacier Bay National Monument (A.S. *33,608*). The spores are cylindrical, 11–13 × 3.0–3.5 μ, 0- to 1-septate, but giving indication of becoming 3-septate. It is too cylindrical for *Stagonospora agrostidis* and probably too short for *Septoria nodorum*. This is a new host for *A. sorghi*.

STAGONOSPORA VEXATULA Sacc. occurs on a herbarium fragment of *Deschampsia beringensis* Hulten collected by Frank Beals on St. Matthew's Island (A.S. *33,798*). This species of *Stagonospora* has been discussed earlier (**16**, **17**) and the few spores seen in Beals's collection are representative. Associated are a few spores of *Curvularia geniculata* (Tr. and Earle) Boed. plus several pycnidia of *Selenophoma everhartii* (Sacc. and Sydow) Sprague and A. G. Johnson. There has been no earlier report of any fungi on this arctic species of *Deschampsia*. We also determine *S. vexatula* on *D. caespitosa* from the Yankee Basin, Tongass National Forest (A.S. *37,044*). The spores were 28–61 × 3.8–6.0 μ.

PHAEOSEPTORIA FESTUCAE Sprague occurs on dead leaves of *Festuca altaica* Trin. on Eagle Summit, collected June 22, 1949. The spores are typical for *P. festucae* (**16**). *F. altaica* is also unreported as a host for fungi. The material (A.S. *37,002*) was obtained from the phanerogamic collections of the Juneau Botanical Society, as was Beals's material of *D. beringensis*, above-mentioned.

Phaeoseptoria festucae also occurs on dead leaves of *Poa pratensis* L. with other fungi in the city park, Juneau (A.S. *37,026*). The young 5- to 7-septate spores vary from hyaline to yellow brown, depending on maturity. They are 35–55 × 2.2–3.1 μ, which places them close to *P. poae* in size. However, the spores are not filiform but clavulate, curved with a pointed apex and have a tapered, but blunted, base. They appear to be young spores of *P. festucae*. We also noted *P. festucae* on dead leaves of *Hordeum brachyantherum* Nevski from Tlingit Point, Glacier Bay National Monument. The spores were 5- to 9-septate and up to 65 μ long (A.S. *37,086*).

HENDERSONIA CULMICOLA Sacc. also occurs on *Festuca altaica* on a

specimen collected by Beals on Unalaska Island (A.S. *33,799*). The spores were 3- to 7-septate, fusiform-cylindrical, 14–22 × 2.6–3.0 μ and typical of mature specimens of this widely distributed saprophyte. Associated was the equally widely distributed *Fusarium nivale* (Fr.) Ces.

The ASCOCHYTA phase of STAGONOSPORA SIMPLICIOR Sacc. and Berl. was found on *Agropyron trachycaulum* (Lk.) Malte at Cooper Station 26 (A.S. *33,625*) and at the same place on *A. latiglume* (Scribn. and Sm.) Rydb. (A.S. *37,021*). This is in an exposed deglaciated area covered mostly with *Salix* thickets near Russell Island, Reed Inlet, Glacier Bay National Monument. The pycnidia were on old leaves and sheaths in vague tawny or straw-colored areas. The spores are irregularly cylindrical, 1- to 2-septate, hyaline or lightly tinted, with one or several large oil drops in each cell. The spores are 25–35 × 9–12 μ. This material could pass for *Ascochyta utahensis* Sprague, which is the common large-spored *Ascochyta* on *Agropyron* spp. in certain arid parts of the Far West (**14**). However, the Alaskan material strongly indicates a true *Stagonospora* with eventually multiseptate spores. I have seen spores of *A. utahensis* on *Elymus condensatus* Presl from Silvies, Oregon, that equalled the size of the Alaskan collection, but the Oregon material lacked the coarse protoplasm of *St. simplicior* (**17**). While *St. simplicior* is common on *Festuca, Stipa* and *Melica* in the mountains of the western United States (**15, 16, 18**), its presence on *Agropyron* is possibly a local adaptation favored by the unusual circumstances of this deglaciated area.

SELENOPHOMA DONACIS var. STOMATICOLA (Bauml.) Sprague and A. G. Johnson was noted on dried foliage of *Puccinellia paupercula* var. *alaskana* Fern. and Weatherb. growing near tide mark on a small island in Hugh Miller Inlet at Cooper Station 33. This material was so atypical that it was first believed to be an undescribed species of *Septoria* with curved, 1-septate spores (FIG. 1,a). The firm, compact brown pycnidia (70–100 μ) are scattered or loosely grouped in leaf, culm and sheath parts. The hyaline spores are falcate to obclavate-falcate, that is, curved with slightly swollen bases. The average 17–25 × 1.4–2.0 μ diam. I have never seen septations in *Selenophoma* except in overwintered material of *S. donacis* on coarse reed grasses. Under the harsh conditions of the shoreline in this exposed area, apparently septations developed during the current season. This kind of material needs study in pure culture. On the basis of general morphology, it is closer to *S. donacis* var. *stomaticola* than to any known species of *Septoria*.

Typical *Sel. donacis* var. *stomaticola* is associated with a perithecial phase (*Metasphaeria culmifida* Lind) on *Trisetum spicatum* (L.) Richt.

in the Mendenhall Glacier area (A.S. *24,369* at Crocker Station 3a). Another collection of *Selenophoma* on this same host a short distance away (Crocker Station 4, deglaciated about 1932–33) had smaller spores and is referred to *Sel. everhartii* (Sacc. and Sydow) Sprague and A. G. Johnson (A.S. *33,782*). This last-mentioned species occurs on *Dupontia fischeri* R. Br. Ssp. *psilosantha* (Rupr.) Hult. on St. Matthew's Island (A.S. *33,797*) collected by Frank Beals in 1944. We also found another fragment of *S. everhartii*, this time on *Arctagrostis latifolia*

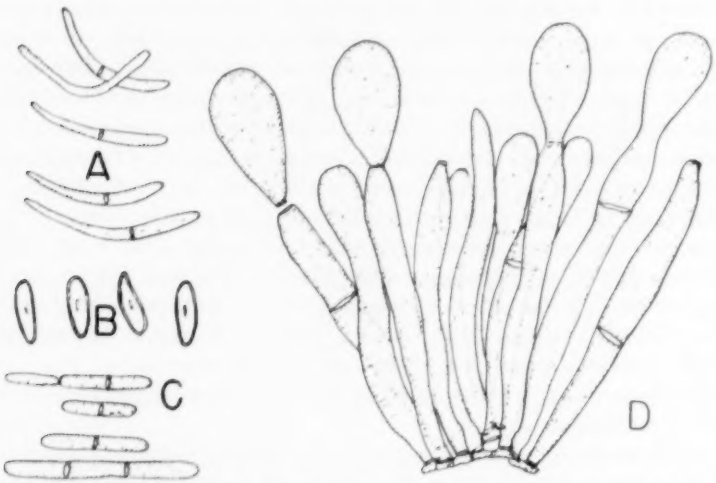


FIG. 1,*a*. Pycnospores of *Selenophoma donacis* var. *stomaticola* on *Puccinellia paupercula* var. *alaskana* at Cooper Station 33, Hugh Miller Inlet. *b*. Pycnospores on *Coniothyrium psammae* on *Calamagrostis canadensis* var. *scabra*, Unalaska Island. *c*. Conidia of *Cylindrocarpon ehrenbergii* on *Poa alpina*, Cooper Station 26, Reed Inlet, Glacier Bay National Monument. *d*. Conidia and conidiophores of *Acremoniella* on *Calamagrostis canadensis*, Tongass Nat'l For.

All drawings made with the aid of a camera lucida, × 1,000.

(R. Br.) Griseb. on a herbarium specimen of Beals from St. Matthew's Island (A.S. *37,001*).

As mentioned earlier, *Darluca filum* (Biv.) Cast. is prevalent on grass rusts in Alaska (**16**). We noted some especially severely parasitized material of *Puccinia poae-sudeticae* (Westd.) Jørstd. on *Phleum alpinum* L. in the city park at Juneau, July 7, 1952 (A.S. *33,725*). The material showed well-defined spots which sometimes extended the entire width of the leaf. The prominent and numerous black pycnidia suggested a lesion comparable to *Selenophoma obtusa* Sprague and A. G.

Johnson and at first glance did not resemble most material parasitized by *Darluca*. It is interesting to note that the only rust on alpine timothy is leaf rust (**3**, **4**, **19**). Cash (**4**) does not report stem rust (*P. graminis*) on any species of timothy from Alaska. While this paper makes no attempt to include discussion of the leaf rusts, it has been necessary to study many collections of them because they involve associated leaf fungi other than rusts. *P. poae-sudeticae* was very often encountered on alpine timothy, on *Poa* spp., especially in the Glacier Bay National Monument, and on *Trisetum spicatum*, often with other fungi.

CONIOTHYRIUM PSAMMAE Oud. is associated with buff dead areas or spots on leaves of *Calamagrostis canadensis* var. *scabra* on Unalaska Island. The yellowish elliptical spores were 7–11 × 3.0–3.5 μ and therefore slightly smaller than the ones we reported from Oregon a number of years ago on *C. nutkaensis* (**11**). The spores appear double-walled (FIG. 1,b), but this may be due to slight plasmolysis plus the presence of the large central body or nucleus mentioned earlier (**11**). The spores are actually somewhat lens-shaped as can be seen by rolling them from side to side under the cover glass.

HENDERSONIA CRASTOPHILA Sacc. was also found on the above-mentioned fragment (A.S. *37,006*) taken from a herbarium sheet of Frank Beals. This fungus is common on dead grass parts in Alaska (**4**, **12**, **16**). Among other collections noted is one on *Arctagrostis latifolia* var. *arundinacea* (Trin.) R. Br. from Naknek. The spores in this material were 20–35 × 4.3–5.0 μ. We also include some material on *Cinna latifolia* (Trev.) Griseb. in *H. crastophila*. This specimen, which was collected at Tlingit Point, Glacier Bay National Monument, has numerous scattered large brown to black pycnidia in bleached to fuscous areas on dead leaves (A.S. *37,030*). The spores are subhyaline to light brown and mostly less than 50 μ long but some range up to 70 μ long. The longer spores are as much as 5.2 μ wide and somewhat constricted at the 7–9 septations. These longer spores resemble those of *Phaeoseptoria calamagrostidis*. They are relatively few in comparison with the many typical *Hendersonia* spores. From their appearance they are probably *Hendersonia* spores which had just started to germinate before drying in the packet. Most of the spores are only 7-septate, flattened on one side, frequently bent at the base by crowding inside the pycnidium and are more readily assignable to *H. crastophila* than to *Phaeoseptoria*. The fungus is associated with *Mycosphaerella tulasnei*, the conidial stage of which is present in great profusion in black

streaks on the leaves. The conidiophores are especially stout (5–6 μ wide) but the spores can be classed as *C. herbarum*.

Hendersonia crastophila on *Poa annua* L. at Hoonah, Alaska (A.S. *37,087*) has pale yellow, curved spores 5–7 septate, 25–35 × 3.6–4.5 μ, not too distinct from *H. culmicola* except that most of them are curved, less often straight. The pycnidia are large typical of *H. crastophila*, however. Numerous hyaline microspores (*Phyllosticta* sp.) occur in pycnidia associated with the ones containing the *Hendersonia* spores. The cylindrical microspores are 5–7 × 0.9–1.2 μ.

Undeterminable material of a definite leafspot on *Cinna latifolia* (Trev.) Griseb. was found in woods at Tlingit Point [(Cooper plots A and B, 1916 series) (A.S. *33,752* and *37,091*)] in the Glacier Bay National Monument, August 20, 1952. The small black substomatal fruiting bodies are abundant in brown, dead areas on living leaves. These bodies are subglobose, erumpent, ostiolate, black, carbonaceous with brittle walls and contain nothing inside except prosenchymatous material. The "perithecia" are 55–100 × 45–60 μ. The only fungi from the western and northern region with ostiolate fruiting bodies on drooping woodreed are the above-mentioned *Hendersonia crastophila*, *Septoria nodorum* Berk. and *Stagonospora arenaria* Sacc. The fruiting bodies are very different from those of *H. crastophila* or *St. arenaria* while the absence of any pycnospores, plus the very black, brittle walls of the fruiting bodies of A.S. *33,752*, also appears to eliminate *S. nodorum*. The parasite is similar in some ways to *Mycosphaerella deschampsiae* (**18**). It also has some resemblance to a collection of *Septoria calamagrostidis* (Lib.) Sacc. on *Trisetum cernuum* Trin. from the Tongass National Forest (A.S. *37,095*) which was mentioned earlier. Because the fungus on *Cinna* does represent an addition to the Alaskan fungus flora, it is mentioned here and the specimens filed (A.S. *33,752* and *37,091*).

SEPTOGLOEUM OXYSPORUM Sacc., Bomm. and Rouss. was noted on a fruiting plant of *Hordeum brachyantherum* Nevski at Sandy Cove, Glacier Bay National Monument. This is the only report of this fungus on *Hordeum* from western America. Since the material consisted of only one well-defined char spot on a mature seed-producing barley plant, its presence on this host must be considered as more or less accidental. The slide mount is preserved as A.S. *33,754*.

CYLINDROCARPON EHRENBERGII Wr. was, in part, associated with *Puccinia poae-sudeticae* on *Poa alpina* L. at Cooper Station 26, Reed Inlet, Glacier Bay National Monument. The fungus formed a black to sometimes salmon-colored or copper-tinted, sub-gelatinous, later stromatic growth on the leaves. The leaves were somewhat matted together.

The numerous spores were hyaline, 1- to 2-septate, cylindrical or slightly larger at one end (FIG. 1,c), 13–30 × 2.1–2.8 μ. The spores appear to be somewhat narrow for *C. ehrenbergii*. This diagnosis is, therefore, somewhat tentative, awaiting possible study later with pure cultures.

SPERMOSPORA SUBULATA f. CILIATA Sprague was found on *Poa trivialis* L. at Steep Creek, Mendenhall Recreation Area, Alaska (A.S. *33,614*). The 1- to 3-septate spores were 25–42 × 3.4–5.0 μ with an obliquely attached pedicel at the base of some spores. The spores are similar to those illustrated for type material (**16**, Fig. 80,a) except that the body of the spore is stouter, such as illustrated for material on *Deschampsia* (**16**, Fig. 80,b; cfr. spore lying next to "b"). The spores occur in tawny areas on living leaves. Rust (*Puccinia poae-sudeticae*) occurs in this material but is not particularly associated with the tawny spots. A fragment of *S. subulata* was also found on *Poa arctica* R. Br. growing high on Mt. Gastineau (A.S. *33,756*). A few scattered spores of *S. subulata* was seen on *Festuca rubra* L. from Beartrack Cove, Glacier Bay National Monument (Sprague *900*, specimen not filed). *S. subulata* was noted in association with discolored spots on *Trisetum spicatum* (L.) Richt. in the Mendenhall Glacier area (A.S. *37,049*).

MASTIGOSPORIUM RUBRICOSUM (Dearn. and Barth.) Nannf. caused a reddish eyespot on *Agrostis stolonifera* L. at Herbert River Recreation Area, Tongass National Forest (A.S. *33,623*). The grass has been reported from Astoria, Oregon as a host for *M. rubricosum* (**9**). The Alaskan specimen appears to be identical. Incidentally, *A. stolonifera* is more prevalent along the coast of North America than is generally recognized, but it appears to be more common in Alaska than in Oregon.

Scanty material of *M. rubricosum* was found on *Agrostis aequivalvis* (Trin.) Trin. near Auk Village in muskeg (A.S. *33,726*). Better material of the same fungus was collected on *A. exarata* Trin. in the Mendenhall Valley at the junction of Montana Creek rd. and Auk Bay rd. (A.S. *33,781*). The short, purple-headed host is similar to *A. exarata* var. *purpurascens* Hult., which Anderson suggests may be a hybrid of *A. exarata* and *A. alaskana* Hult. (1). The fungus was also found on *A. exarata* on the Yankee Basin Trail, Tongass National Forest (A.S. *37,060*).

Another collection of *M. rubricosum* on *Phleum alpinum*, this time with adequate numbers of spores present, was found in a brushy area near the Mendenhall Glacier. The spores were short, 26–31 × 10–11 μ and similar to material on *Agrostis*.

OVULARIA PUSILLA (Ung.) Sacc. and D. Sacc. continues to be found on more and more unreported hosts. The spots are usually small, the

conidiophores often almost impossible to see with a hand lens, and the spores in mounts are more often than not limited to a few immature egg-shaped hyaline ones widely scattered through the mount. This fungus causes small reddish elliptical eyespots on *Poa laxiflora* Buckl. growing on a rocky wooded slope on Sebree Island in the Glacier Bay National Monument (A.S. *33,731*). This appears to be the first parasitic fungus reported on this host. Immature material of this same fungus on *P. laxiflora* was also found along a large creek at Tlingit Point not far from A.S. *33,731* (A.S. *37,041*). *P. laxiflora* is apparently considered as rare although we have encountered it a number of times in Alaska. We recently mentioned (**18**) that *Ovularia*-like spores were in the type of *Mycosphaerella deschampsiae*. Some material in the Mendenhall Valley also includes *O. pusilla* and immature perithecia of *M. deschampsiae*, but the two fungi are in separate lesions in all cases. One collection in the Mendenhall area contains *O. pusilla* only (A.S. *37,076*). We have seen *O. pusilla* on *Deschampsia atropurpurea* in a number of places in the Tongass National Forest. The buff lesions resemble those reported earlier on *Glyceria* (**18**). The fungus causes narrow, chocolate brown streaks (immature) on some herbarium material of *Arctagrostis latifolia* (R. Br.) Griseb. collected by Frank Beals on St. Matthew's Island, August 13, 1944 (A.S. *33,800*). The spores were small and immature. We also have a more abundant collection of *Ovularia* on *Hordeum brachyantherum* Nevski from Sandy Cove, Glacier Bay National Monument (A.S. *37,028*). The very abundant spots are dark chocolate brown streaks and elliptical lesions on the leaves and sheaths. This collection, unfortunately, was included in some of the material collected during prolonged rains and then dried on the galley stove of the M. S. Taku; and it was only after diligent search that we were able to find a few determinable spores and conidiophores. Associated is some equally cooked tissue of *Septoria passerinii*, including microspores. This collection represents the first one of *O. pusilla* on *Hordeum* from the western and northern area that we have recognized. Similar material on the same host was collected at Beartrack Cove (A.S. *37,057*); also in the Glacier Bay region. Several collections of similar appearing, but entirely sterile spots, on this wild barley were discarded earlier in the study as undeterminable. The host may be somewhat resistant to this fungus.

O. pusilla occurs on *Calamagrostis canadensis* var. *scabra* along the Yankee Basin Trail, Tongass National Forest (A.S. *37,082*). Scattering spots occur on leaves of *Agropyron repens* (L.) Beauv. on Sebree Island, Glacier Bay National Monument (A.S. *37,085*).

RHYNCHOSPORIUM ORTHOSPORUM Caldwell, which is common on grasses in the Tongass National Forest, was found on *Poa laxiflora* Buckl. along the trail to Yankee Basin from Eagle River, growing among ferns. This specimen (A.S. *33,768*) is the first collection of this fungus on *Poa*. I have never encountered a region where fungi crossed over onto new or unreported hosts as frequently as they do in southeastern Alaska.

COLLETOTRICHUM GRAMINICOLA (Ces.) Wils. and *Fusarium nivale* (Fr.) Ces. were found in trace quantities on the ornamental striped reed canary grass (*Phalaris arundinacea* var. *picta* L.) growing on the grounds of the Governor's estate at Juneau. This grass is highly resistant to most fungi and it proved to be so to these also. The injury was scarcely noticeable.

HELMINTHOSPORIUM TRITICI-REPENTIS Died. was common on *Agropyron subsecundum* (Lk.) Hitchc. at Windfall Lake, near the Herbert River, Tongass National Forest (A.S. *33,598*). The large immature perithecia of *Pleospora trichostoma* (Fr.) Ces. and de Not (*Pyronophora tritici-repentis* [Died.] Drechsl.) were forming on current-season leaves. Lefebvre found *H. tritici-repentis* on *Elymus innovatus* in Mt. McKinley Park (**4**). The fungus is probably common in Alaska as it was also in Oregon (**10**) and North Dakota (**16**).

HETEROSPORIUM PHLEI Gregory caused typical reddish-mauve spots on living leaves of *Phleum alpinum* L. at Cooper Station 26, Reed Inlet, Glacier Bay National Monument (A.S. *33,611*). Conidiophores on dead leaves were so numerous that the leaves appeared hairy. The dark conidiophores ranged from 100–150 μ high and 7–9 μ thick. The spores were 21–28 $\times$ 7.5–10 μ. We have also occasionally seen the saprophyte *H. avenae* Oud. in small quantities on various dead grasses. One specimen of *Poa stenantha* from Red Mountain, Glacier Bay area, shows abundant sporulating material of *H. avenae* on the lower leaves of current-season grass. The fungus appears to be secondary following a scald caused by *Fusarium nivale* (Fr.) Ces.

ACREMONIELLA sp. occurs in black streaks on yellowed areas of living leaves of *Calamagrostis canadensis* var. *scabra* along the lower Herbert River, Tongass National Forest (A.S. *37,022*). The long bottle-shaped or nearly cylindrical conidiophores are closely packed in the elongate black strips. A slight hilum scar is left at the slightly tapered or blunted apex of the conidiophore after the bright brown conidia are broken off. The conidiophores are 40–50 $\times$ 4.0–5.5 μ, usually sparsely septate and arising in dense clumps (FIG. 1,d). The spores are borne small end attached to the conidiophore, are aseptate, 14–22

× 11–15 μ and are formed by expansion of the apex of the conidiophore and final abscission.

There is a very detailed study of *Acremoniella* and related forms by Mason (**6**) and later by Groves and Skolko (**5**). Critical study of these and other articles still leaves me in doubt as to the identity of the Alaskan fungus. *Acremoniella* has typically long conidiophores (aleuriphores) with sharply pointed apices. The apices of the conidiophores in our material are more like those of *Monotospora daleae* Mason, but the conidiophores are too long. Perhaps the differences we note may be that our studies deal with material on a living host while much of that studied by Mason and by Groves and Skolko was from pure culture material. Our fungus has greater resemblance to a one-celled *Scolecotrichum* than to any illustrations of *Acremoniella* available.

I compared our fungus with *A. occulta* Cav. which has been called *Monotospora occulta* (Cav.) Viull., and also a synonym of *Nigrospora oryzae* (B. & Br.) Petch (**6**). However, our specimen does not seem to be related. *A. occulta* produces a flaky, yellow-brown growth on culms and sheaths of some cereals. I also compared our specimen with *A. verrucosa* Togn.; but this fungus has globose, roughened spores (**4**). Ours has spores very similar to those shown for *A. atra* (Corda) Sacc. (**5**) except that they are smaller than the ones measured by Groves and Skolko. The status of *A. atra* is uncertain. The type is apparently lost and the description of the fungus based largely on a restudy by Caccardo (**7**). Everything considered, we prefer to assign our fungus only to the genus.

HELMINTHOSPORIUM CYCLOPS Drechsl. was found on dead leaves of *Trisetum spicatum* (L.) Richt. at 2,000 feet on the slopes of Red Mountain, Glacier Bay National Monument (A.S. *37,068*) in association in part with *Septoria calamagrostidis* (A.S. *37,067*). *H. cyclops*, which is now believed to be the same as *Podosporiella verticillata* O'Gara or *Pleosphaeria semeniperda* (**20**), is unreported on *Trisetum*. I can find no mention of *Helminthosporium* on this host in North America. The Alaskan material consists of a few leaves which are liberally covered with unbranched stout brown conidiophores bearing the typical thick-walled, cigar-shaped spores of *H. cyclops*. The hilum is prominent, the spores mostly 7-septate and up to 100 × 16 μ.

SEPTORIA AVENAE Frank with yellowish spores occurs in whitened areas on living leaves of *Calamagrostis canadensis* var. *scabra* at the edge of a thicket in the Herbert River valley at the end of the auto road, Tongass National Forest (A.S. *37,023*). This is the same kind of fungus that was reported earlier on *Agrostis borealis* from Mt. Gastineau

(**18**). The spores are badly shriveled but a few are not plasmolyzed. They are cylindrical, 3-septate, 17–28 × 3.0–3.4 μ and are pale chalcedony yellow in color. The pycnidia range to 150 μ diameter. This material was collected at the same place as was the *Acremoniella* specimen, but the two fungi are not associated on the same leaf. *S. avenae* is unreported on var. *scabra*, but it has been collected in Montana and Utah on the species proper.

OPHIOBOLUS GRAMINIS Sacc. caused typical stunting and black basal decay in *Agrostis exarata* Trin. (A.S. *37,053*) growing in sand in a recently dry bed of the Mendenhall Glacier, dating no earlier than 1945 (station G 9). The plants had started and grown luxuriantly near the remains of a salmon in the otherwise sterile soil. Apparently, the nitrogen had become exhausted and *Ophiobolus* moved into the plants. It was seen on other hosts in the area, especially on *Festuca ovina* var. *brachyphylla* (A.S. *24,371*). This fungus is favored by a shortage of nutrients, especially nitrogen.

ERYSIPHE GRAMINIS DC. was abundant along the main street in Hoonah, Alaska on *Bromus sitchensis* Trin., an unreported host (A.S. *33,577; 37,078*). The dried material shows large chocolate-brown lesions.

LITERATURE CITED

1. **Anderson, J. P.** Flora of Alaska and adjacent parts of Canada. Iowa State College Jour. of Sci. **18** (4): 381 (402)–445. 1944.
2. ——. Some Alaska fungi. Proc. Iowa Acad. Sci. **27**: 99–108. 1920.
3. **Arthur, J. C.** Manual of the rusts of the United States and Canada. Purdue Res. Foundation. 1943.
4. **Cash, Edith K.** A check list of Alaskan fungi. Plant Dis. Rep. Suppl. 219. Feb. 15, 1953.
5. **Groves, J. W. and A. J. Skolko.** Notes on seed-borne fungi IV. *Acremoniella, Chlamydomyces* and *Trichocladium*. Canad. Jour. Res. C, **24**: 74–80. 1946.
6. **Mason, E. W.** Annotated account of fungi received at the Imperial Bureau of Mycology. List II, Fasc. 2. 1933.
7. **Saccardo, P. A.** Sylloge fungorum IV. Patavii. 1886.
8. ——, **C. H. Peck, and Wm. Trelease.** The fungi of Alaska. Harriman Alaska Expedition **5**: 13–64. Illus. 1904.
9. **Sprague, R.** Two *Mastigosporium* leafspots on Gramineae. Jour. Agric. Res. **57**: 287–299. Illus. Aug. 15, 1938.
10. ——. A revised check list of the parasitic fungi on cereals and other grasses in Oregon. U.S.D.A. Bur. Pl. Ind. Pl. Dis. Rep. Suppl. **134**, 36 pp. (Processed) Mar. 1, 1942.
11. ——. Some leafspot fungi on western Gramineae. Mycologia **33**: 655–665. 1941.

12. ——. The status of *Septoria alopecuri* and some related species. Mycologia **35**: 259–263. 1943.
13. ——. Septoria disease of Gramineae in western United States. Oregon State College Monograph Studies in Botany No. 6. 151 pp. Illus. 1944.
14. ——. Some leafspot fungi on western Gramineae—III. Mycologia **40**: 295–313. 1948.
15. ——. Some leafspot fungi on western Gramineae—IV. Mycologia **41**: 493–504. 1949.
16. ——. Diseases of Cereals and Grasses in North America. The Ronald Press, 538 pp. 81 figs. 1950.
17. ——. Some leafspot fungi on western Gramineae—VI. Mycologia **43**: 549–569. 1951.
18. ——. Some leafspot fungi on western Gramineae—VII. Mycologia **46**: 76–88. 1954.
19. —— **and G. W. Fischer.** Check list of the diseases of grasses and cereals in the western United States and Alaska. Washington Agricultural Experiment Station Circ. 194. September, 1952.
20. **Wallace, H. A. H.** A rare fungus disease of cereal seed. Phytopathology **40**: 30 (abs.). 1950.

VERA K. CHARLES

Edith K. Cash

In the death of Vera K. Charles in Washington, D. C., on November 2, 1954, after an illness of several weeks, the Mycological Society has lost a member whose work and influence in mycology will long be remembered.

Miss Charles was born in Erie, Pennsylvania, on June 24, 1877. Her early years were passed at Glen Echo Heights, a Maryland suburb of Washington, D. C., but later she made her home in the city. She attended Mt. Holyoke College and Cornell University, obtaining her A.B. degree in 1903 at the latter institution, where she also took graduate work in mycology with the late Prof. George F. Atkinson. She came directly from Cornell to the Bureau of Plant Industry of the Department of Agriculture in 1903, and carried on her work in the Office of Mycological Collections and its successors from that date until her retirement from government service on June 30, 1942. After retirement she continued work as a collaborator of the Division of Mycology and Disease Survey until failing eyesight made it imperative for her to give up her microscopic studies. To the time of her death, however, she maintained an undiminished interest in current literature in mycology and phytopathology.

Miss Charles will probably be best remembered for her work on the agarics, particularly the identification of edible and poisonous mushrooms, being for many years the expert in this field for the government service. The bulletin on "Mushrooms and other common fungi" published in 1915 with Flora W. Patterson, and the later bulletin on the same subject in 1917 were widely known and highly regarded. The more recent circular, "Some common mushrooms and how to know them," issued in 1931 and twice revised, is still in great demand and one of the most frequently requested publications of the Department of Agriculture.

Her mycological interests were by no means confined to the Agaricaceae. During her early years in the Department, before the passage of the Plant Quarantine Act in 1912, Miss Charles carried on a large part of the pathological inspection of imported plants received by the Department. This work involved the study of a wide variety of organisms in the Ascomycetes and Fungi Imperfecti. Of the latter group,

in particular, she possessed a remarkably comprehensive knowledge, only slightly reflected by her publications on plant pathogens of such diverse crop plants as pineapple, hemp, sweet pea, and rubber. Her later papers indicate an increasing interest in the entomogenous fungi and in fungi pathogenic to man and animals. Florida fungi were also one of her interests and she spent several winters making mycological collections in the vicinity of Winter Park, and in other parts of Florida, accompanied on some of her trips by Dr. C. L. Shear and by the late Dr. Gertrude Burlingham.

In addition to the mycological publications listed below, Miss Charles prepared descriptions of several new species of fungi published in articles by other authors, including Perley Spaulding, James R. Weir, and C. L. Shear.

MYCOLOGICAL PUBLICATIONS OF VERA K. CHARLES

1906. Occurrence of *Lasiodiplodia* on *Theobroma cacao* and *Mangifera indica*. Jour. Myc. **12**: 145–146.

1910. Some fungous diseases of economic importance. I. Miscellaneous diseases (Flora W. Patterson, senior author). II. Pineapple rot caused by *Thielaviopsis paradoxa* (with Flora W. Patterson, senior author, and F. J. Veihmeyer). U. S. Dept. Agr. Bur. Pl. Ind. Bull. 171, 41 p., illus.

1914. A fungous disease of hemp. Jour. Agr. Res. **3**: 81–84, illus. (with Anna E. Jenkins).

1915. Mushrooms and other common fungi. U. S. Dept. Agr. Bull. 175, 64 p., illus. (Flora W. Patterson, senior author).

1916. Mushrooms and some other common fungi. In Boy Scouts of America. Official Handbook, p. 167–179, illus.

The occurrence of bamboo smut in America. Phytopath. **6**: 351–356, illus. (Flora W. Patterson, senior author).

1917. Some common edible and poisonous mushrooms. U. S. Dept. Agr. Farm. Bull. 796, 24 p., illus. Reprinted 1922.

1922. Notes: *Cenangium balsameum* Pk. var. *abietinum* Pk. and *Septoria argemones* Tharp. Path. Herb. Notes **4**: 11, 12.

1923. Notes: *Scleropycnium aureum* Heald & Lewis and *Ustilago vittata* Nees. Path. Herb. Notes **6**: 9, 10.

1925. Mushrooms—How to tell whether edible or poisonous. The Nation's Health **7**: 456–459; 542–545, illus.

1928. Some mushroom diseases and their carriers. U. S. Dept. Agr. Circ. 27, 9 p., illus. (with C. H. Popenoe). Revised, 1930.

Preliminary studies of the life history of *Erostrotheca multiformis*, the perfect stage of *Cladosporium album* Dowson. Phytopath. **18**: 839–846, illus. (G. H. Martin, senior author).

1929. Mrs. Flora Wambaugh Patterson. Mycologia **21**: 1–4, portrait.

Coleodictyospora, a new genus of Dematiaceae. Phytopath. **19**: 1051–1053, illus.

Mushroom culture for amateurs. U. S. Dept. Agr. Farm. Bull. 1587, 16 p., illus. Revised, 1933.

1931. Some common mushrooms and how to know them. U. S. Dept. Agr. Circ. 143, 60 p., illus. Revised 1946 and 1953.

1933. Spores in the upper air. Phytopath. **23**: 23 (abstract) (with F. C. Meier, senior author, and John A. Stevenson).

Plaster molds occurring in beds of the cultivated mushroom. Jour. Agr. Res. **46**: 1089–1098, illus. (with Edmund B. Lambert).

1934. *Microsporum* of cats causing ringworm in man. Jour. Wash. Acad. Sci. **24**: 222–227 (with Aline F. Kempton).

The Mycologist. In Filene, Catherine, Careers for women, p. 524–528.

1935. A little known pecan fungus. Mycologia **27**: 74–82, illus.

The recovery of a pathogenic fungus from leucocytes. Mycologia **27**: 322–323.

1936. The synonymy of *Botrytis rileyi* Farlow. Mycologia **28**: 397–398.

1937. A fungus on lace bugs. Mycologia **29**: 216–221, illus. 1937.

1938. A new entomogenous fungus on the corn earworm, *Heliothis obsoleta*. Phytopath. **28**: 893–897, illus.

A note on the occurrence of *Marasmius pyrinus*. Mycologia **31**: 228–230, illus.

1939. Noteworthy Florida and Georgia fungi. Pl. Dis. Rep. **23**: 130–133.

Notes on entomogenous fungi. Pl. Dis. Rep. **23**: 340.

1940. An entomogenous fungus on spider mites on water hyacinth. Mycologia **32**: 537–540.

A ringworm disease of muskrats transferable to man. Jour. Wash. Acad. Sci. **30**: 338–344.

1941. A fungus disease of codling moth larvae. Mycologia **33**: 344–349, illus. 1941.

A fungus parasite of the mealy bug. Phytopath. **31**: 7 (abstract) (with Couch, J. N., J. G. Harrar, and J. J. McKelvey, Jr.).

A preliminary check list of the entomogenous fungi of North America. Insect Pest Surv. Bull. 21 (Suppl. to no. 9): 707–785.

1942. Mushroom poisoning caused by *Lactaria glaucescens*. Mycologia **34**: 112–113.

A *Laschia* on cabbage palmetto. Mycologia **34**: 235–240, illus.

A new yellow *Lepiota*. Mycologia **34**: 322–324, illus.

PLANT INDUSTRY STATION, U. S. D. A.,
BELTSVILLE, MARYLAND

NOTES AND BRIEF ARTICLES

CYATHUS GAYANUS FROM COSTA RICA

Cyathus gayanus Tul. has been known heretofore only from the type collection. Tulasne (**1844**) described it [1] from specimens collected in Chile by Claude Gay who traveled in South America between 1828 and 1842.

This species has been found again among fourteen packets of Nidulariaceae brought back from Costa Rica by Dr. C. B. Heiser and the collection was considered sufficiently noteworthy to justify description and illustration.

The Costa Rica specimens described herein (*No. 1226* in collection of H. J. Brodie) were collected by Doctor and Mrs. Heiser at La Redonda, near San José, Costa Rica at an altitude of about 5000 ft., Aug. 2, 1953. The fungi were growing on rotten wood partly buried in soil.

After studying the type material from Tulasne's herbarium in the National Museum in Paris, Lloyd [2] retained *C. gayanus* as a valid species when he published his monograph of the Nidulariaceae (**1906**). My own study of the type, in 1952, confirmed Lloyd's opinion. It seemed odd, however, that no other specimens could be found in the large European herbaria in which there is abundant representation of material belonging to this group of fungi from South and Central America.

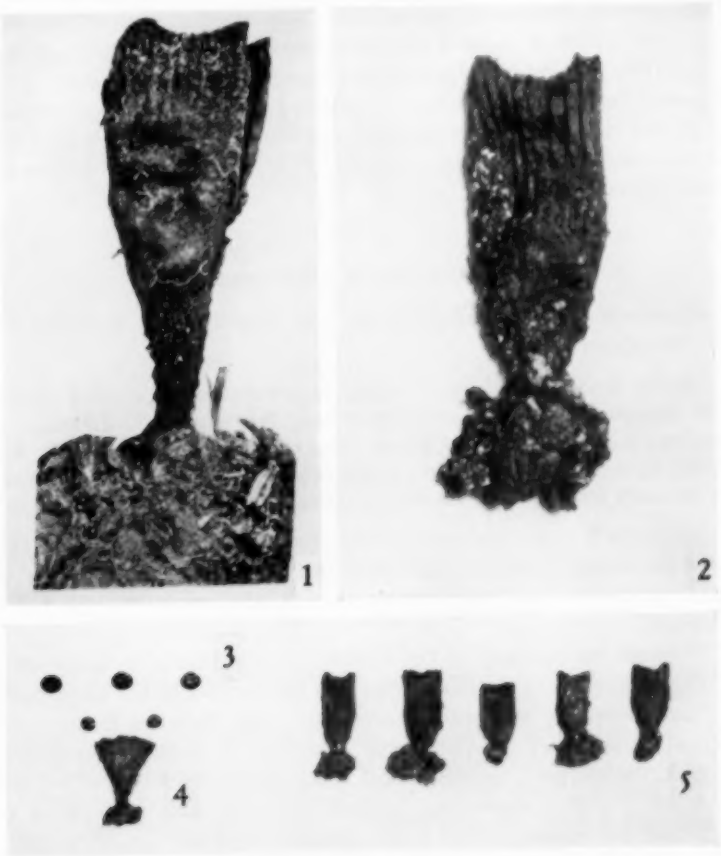
The salient features of *C. gayanus* were paraphrased by Lloyd from Tulasne's description, as follows:

"Peridium about 1½ cm. high, 5–6 mm. broad, narrow, conic, dark brown, striate within and faintly without, strigose, hirsute. Peridioles black, large, 3 mm., with thick outer wall. Spores subglobose, large, varying from 20–32 mm." [3]

The most conspicuous features of the type specimen are the size and shape of the fruit bodies. They are very tall, slender and somewhat cylindrical in comparison with most species of *Cyathus* in which the cups are conical. The color is intense dark brown (between Natal and

[1] Tulasne, L. R. and Tulasne, C. 1844. Ann. Sci. Nat. **3**: 41–107.
[2] Lloyd, C. G. 1906. The Nidulariaceae. Cincinnati, 32 pp.
[3] Obviously a misprint for microns.

Bone Brown of Ridgway). The smooth black peridioles are very large, 3–3.5 mm in diameter. Tulasne gave the spore measurements as 15–17 × 20–22 μ, but Lloyd pointed out that some spores were as large as 32 μ. The type, when I saw it, comprised but four specimens labeled as having been collected by Gay in Chile (no date given). Lloyd's photograph of the type is reproduced in FIG. 1.



FIGS. 1–5.

1. Type specimen of *Cyathus gayanus* Tul. from photograph published by Lloyd (*loc. cit.*), × 4. 2. *C. gayanus* from Costa Rica; single specimen enlarged for comparison with Fig. 1, × 4. 3. The large peridioles of *C. gayanus*, × 1. 4. Two peridioles and one fruit body of *C. poeppigii*, × 1. 5. *C. gayanus* from Costa Rica, × 1.

The Heisers' collection of *C. gayanus* from Costa Rica (FIGS. 2, 3, 5) agrees very well with Tulasne's description. It is probable that the specimens were old when collected because many are somewhat weathered and attempts to induce spores to germinate were unsuccessful. In the peridioles that were sectioned, the thick double cortex is very evident. The spores are very scanty and range from 16–23 × 20–30 μ in size. They are thick-walled, subglobose and often slightly angular.

In general, *C. gayanus* resembles *C. limbatus* Tul., and *C. poeppigii* Tul. From both of these it is distinguished by its tall cylindrical fruit bodies (FIG. 2), its large peridioles (FIG. 3) and large spores. Lloyd suggested relationship between *C. gayanus* and *C. stercoreus* (Schw.) De T., but study of the type material and the Costa Rica specimens does not confirm the suggestion.—HAROLD J. BRODIE, Indiana University, Bloomington, Indiana.

HELMINTHOSPORIUM FLAGELLOIDEUM [1]

Helminthosporium flagelloideum was described by Atkinson [2] in 1897 as follows:

"Spots indefinite, black. Hyphae amphigenous, few in a cluster, stout, fuligenous brown, flexuous, nodulose, 4–8-septate, 50–120 × 7–9 μ. Conidia fuligenous, base elliptical, upper end prolonged into a long hyaline slender flagellum as in Cercospora crassa, 7–9-septate, 70–150 μ. On leaves of Panicum sp. Auburn, 1906, Sept. 1890."

Although *H. flagelloideum* was reported on *Panicum maximum* Jacq. in the Dominican Republic by Ciferri and Fragoso [3] in 1927, it has not been reported in the United States since it was originally collected by Atkinson.

Through the courtesy of Dr. Richard P. Korf the type collection of *H. flagelloideum* was obtained from the Herbarium of the Department of Plant Pathology at Cornell University. The leaves in the type collection showed dark grayish-purple, indefinitely limited, elliptical or, when on the margins, hemi-elliptical spots measuring 20–30 × 3–4 mm. Brownish globules resembling bacterial exudate were present on the surface of the lesions. Only a few conidiophores and conidia could be

[1] Paper No. 237, Journal Series, Georgia Experiment Station, Experiment, Georgia.

[2] Atkinson, G. F. 1897. Some fungi from Alabama. Bull. Cornell University (Sci.) **3** (1): 1–50.

[3] Ciferri, R. and R. Gonzales Fragoso. 1927. Hongos parasitos y saprofitos de la Republica Dominicana (11th ser.). Bol. R. Soc. Espanola Hist. Nat. **27**: 267–280.

found. The conidiophores were cylindrical, simple, moderately dark brown, 84.0–148.4 × 7.0–8.4 μ, and 5–11-septate. The conidia (FIG. 1) were ellipsoid to obclavate, pale to moderately dark brown, 47.6–70.0 × 9.8–16.8 μ, 5–9-septate, and with a rounded base bearing a circular hilum. The apex terminated in a long, slender, hyaline, 0–3-septate beak measuring 28.0–92.4 × 2.8 μ. The conidia, including the beak, were 84.0–156.8 × 9.8–16.8 μ and 5–12-septate. The beak was sometimes forked. Often there was a bud at the base of the beak bearing a

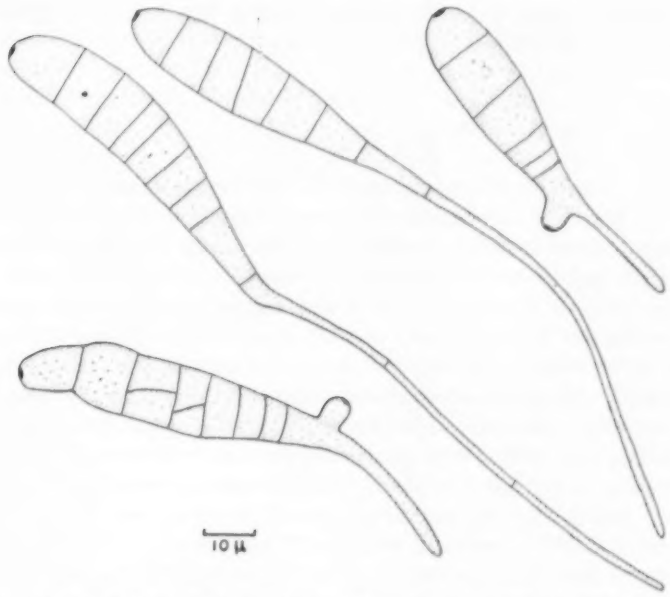


FIG. 1. *Helminthosporium flagelloideum* Atk. Conidia from the type collection.

circular conidial scar which indicated catenulation of the conidia. In a single conidium there appeared to be 1–2 longitudinal septa.

These were the only conidia found in the type collection. They agreed fairly well with Atkinson's brief diagnosis. Despite the lack of longitudinal septa in the conidia, this fungus seems to belong in *Alternaria* rather than in *Helminthosporium* and should be brought to the attention of students of the former genus. It closely resembles *A. dauci* (Kuehn.) Groves & Skolko and *A. linicola* Groves & Skolko,[4] from

[4] Neergaard, P. 1945. Danish species of Alternaria and Stemphylium. Einar Munksgaard, Copenhagen.

which it differs in the smaller conidia, the almost complete lack of longitudinal septa, and occurrence on a gramineous host. *Helminthosporium flagelloideum*, therefore, is transferred to the genus *Alternaria* as:

Alternaria flagelloideum (Atk.) comb. nov.

(*Helminthosporium flagelloideum* Atk.)

The identity of the Dominican fungus collected by Ciferri and Fragoso is doubtful. The species was merely listed in their report without description of their material, and it has been impossible to examine their collection.—E. S. LUTTRELL.

STAUDE REDIVIVUS

In a recent paper on nomenclature questions, Donk [1] insists that some of Staude's subdivisions of the gill fungi are Friesian tribus or subgenera elevated to the rank of genera. Such an interpretation is untenable, as has been pointed out by Rogers.[2] From Donk's first [3] as well as second [1] account and from the text of Staude's rare and forgotten book it becomes clear enough that Staude confused Friesian tribus and genera. This is the only consistent explanation of the use of *Agaricus* in species combinations, and the absence of that genus in the hierarchy above his G[attungen]. Donk is right in saying that there is no rule making new specific combinations necessary for the valid publication of a genus, but there is a difference between the description of new genera not accompanied by new combinations or merely by examples of species with the old binomials left intact, as was frequently done by Fayod, and, on the other hand, the manner in which Staude failed to accept his own as well as previously published "genera" in the very same floristic work when it came to the naming of the species. Donk claims that *Coprinus* (where combinations with *Agaricus* are also left intact) was (in 1857) already generally accepted (?), and says, following the same argument, that all agarics were "popularly known" as *Agaricus* (hence, allegedly, Staude's reverting to *Agaricus*). Since "popularly known" cannot apply to a scientific name, especially not in Germany where an analogue to the English use of "agaric" is unknown, Donk must have meant "generally accepted" which is, in turn,

[1] Reinwardtia **2**: 495–498. 1954.
[2] Farlowia **4**: 22. 1950.
[3] Bull. Bot. Gard. Buitenzorg III, **18**: 319–320. 1949.

in contradiction to his claim regarding *Coprinus*. While this argument is as contradictory in itself as are Staude's "Gattungen," we might still consider the alternative explanation given by Donk which assumes that Staude's reason for inconsistency was the fact that the engraving date of his plates was earlier than the date of his decision to give the Friesian tribus the status of genera (manuscript). But this assumption is not at all supported by facts, lacks probability, and seems to have been made ad hoc. What really happened was that a man totally unqualified to deal with the subject dealt with it nevertheless, but, fortunately, in such a confused manner that uncertainty about the status of his taxa makes it possible to consider them invalid. The fact that there is strictly speaking no genus *Agaricus* to which the Staudean taxa can be subordinated merely adds to this writer's conviction that Staude's so-called classification is but an utterly incompetent compilation. Never and nowhere did Staude, as far as I am aware, even hint that his "Gattungen" were meant to be new status; one gathers the impression that he never even understood that he could or might have been credited with doing such a thing, apparently being ignorant or oblivious of the fact that there is a difference between tribus and genus. In this he differs from Quélet. It is incomprehensible how it could have been implied that a consistent application of the principle indicated by Rogers in regard to Staude would lead to non-recognition of the Queletian genera. Quélet did leave the gender of some of his newly combined epithets unchanged, but this is a common *lapsus pennae*, one that has happened to a majority of taxonomists, and cannot in the least invalidate the fact that Quélet explicitly declares his intention and makes it very clear that his genera are *novi status*. The manner of persuasion employed here in behalf of Staude's alleged genera is rather ill chosen. The author who suggests that non-acceptance of his viewpoint *re* Staude leads to wholesale "murder" of genera forgets that an analogous argument is in order in the case of *Pellicularia*,[4] differing from Donk's own merely in one particular: that it is a valid argument. If it is permitted to consider *Pellicularia* a *nomen confusum* on the basis of the fact that Cooke described spores which, later, were found to be foreign (at least this is Donk's hypothesis), one has no difficulty to point out that in a parallel situation existing in hundreds of species of Basidiomycetes, mostly tropical and "exotic," but some North American or European, authors like Berkeley, Hennings, and Spegazzini described what they thought to be basidiospores while, as often can be proved by reexamination of the types, the spores seen were those of secondary saprophytes, frequently

[4] Reinwardtia **2**: 425–434. 1954.

conidiospores of various moulds. Such species are, however, always considered to be validly published even if proof can be given that basidiospores and basidia did not exist *and* foreign spores as described in the original description as basidiomycetes are present in the type specimens, a condition not fulfilled in the case of *Pellicularia*. This practice of refraining from considering such basidiomycetous fungus names *nomina confusa* is undoubtedly a sound one inasmuch as, in *this* case and *not* in the case of Staude's ambiguity, a wholesale slaughter of available taxa would, by necessity, result, and nothing would be gained by an interpretation of Art. 76 such as suggested by Donk. In all these cases, the only interpretation that can be given to the phrase "unless it is possible to select one of these elements as a satisfactory type" is this: Those authors who have seen fit to select the basidiomycetous portion of the type as the lectotype have done so legitimately, interpreting the contradictory or false statements in the original description as mere errors of observation, and these authors should be given credit in the light of the priority principle now governing the selection of types. If this interpretation of Art. 76 were found to be wrong, the whole article loses its sense because it would leave the way open for doing either one thing or the other (for which no rule is needed). Donk's literature studies leading to the "discovery" of such books as those by Staude and Kummer [5] are meritorious insofar as they complete the background of a number of nomenclatorial questions. It is up to the mycologists to see how they can deal with the problems involved. It is, however, neither correct nor fruitful to insist on the validity of the new status allegedly proposed in those books.—ROLF SINGER, Instituto Miguel Lillo, Tucumán, Argentina.

A NOTE CONCERNING RHIZIDIOPSIS AND PODOCHYTRIUM [1]

Some years ago the senior author erected the genus *Rhizidiopsis* to accommodate a parasite of *Melosira* found growing in a pond in the gardens of Emmanuel College, Cambridge University. It seemed closely allied to *Podochytrium* but so far as could be determined no

[5] In Kummer's case the writer believes he has shown convincingly that Kummer did not propose a new status for the Friesian tribus; he rather proposed new genera, coinciding, according to Kummer's own text, with the tribus names of corresponding groups in Fries's works. It is therefore correct to cite *Tricholoma* Kummer rather than *Tricholoma* (Fr.) Kummer. (See Schweizer. Zeitschr. Pilzk. **29**: 204–228. 1951.)

[1] Contribution from the Department of Botany, University of Michigan No. 1028.

septate sterile basal part to the sporangium could be detected. Further, the cyst of the zoospore characteristically remained unexpanded and appeared as a basal protuberance on the procumbent sporangium. Generally, no intramatrical system could be observed. Another feature of *Rhizidiopsis,* in contrast to *Podochytrium,* was the abundant production of resting spores which appeared as sessile, discoid bodies with a dark-brown rough wall. These, because of their small size must evidently have been derived from the encysted, unexpanded body of the zoospore. Upon germination they produced a non-septate sporangium.

Recently, the junior author has obtained abundant material of a parasite of *Melosira* from the Huron River near Ann Arbor and has maintained it on its host over a considerable period of time. In general appearance and size and prostrate position of the sporangium, size of the zoospore and in the abundant production of small resting spores which readily germinate, this fungus resembles *Rhizidiopsis emmanuelensis* Sparrow. It differs, however, in having a broad, strap-like rhizoidal system and frequent formation of a sterile basal part cut off by a septum.

The general aspect of the sporangium and strap-like rhizoidal system of the Michigan material at once recalled Friedmann's (**1952**)[2] recent description of a *Melosira* parasite from Austria assigned by him to *Podochytrium clavatum* Pfitzer. Here, the sporangium may have a basal sterile stalk, but more frequently it arises directly, as in *Rhizidiopsis,* from the cyst of the zoospore, from which it may or may not be separated by a septum. The rhizoidal system, like that of the Michigan material, is coarse and strap-like.

After a study of the type material of *Rhizidiopsis emmanuelensis,* the Huron River fungus and Friedmann's account of his *Melosira* parasite, we have come to the conclusion that the fungi involved are almost, if not, identical. However, if we are to accept Zopf's (**1888**) interpretation of Pfitzer's *Podochytrium clavatum,* as has been universally the practice, the parasites of *Melosira* cannot be included in it. This comes about not only from the fact that in the *Melosira* parasites the sporangium is usually sessile on the unexpanded cyst of the zoospore, but primarily because of the difference in the nature of the rhizoidal system. According to Zopf's description and figures, the rhizoidal system of his material was extremely fine and delicate whereas in the parasites of *Melosira* it was coarse, strap-like and mycelial as in the larger, strongly stalked *Podochytrium cornutum* Sparrow.

[2] Friedman, I. 1952. Über neue und wenig bekannte auf Diatomeen parasitinende Phycomyceten. Österr. Bot. Zeit. **99**: 173–219.

For these reasons, we advocate the suppression of *Rhizidiopsis* and the assembling under the binomial **Podochytrium emmanuelensis** (Sparrow) Sparrow and Paterson, comb. nov. of the forms on *Melosira* observed by Sparrow, Paterson and Friedmann.

PODOCHYTRIUM Pfitzer, Sitzungsber. Niederrhein. Gesell. Natur- und Heilkunde (1869) (*in* Verhandl. Naturhist. Vereins Preuss, Rheinl. u. Westphalens. **27**: 62. 1870).
Septocarpus Zopf, Nova Acta Acad. Leop.-Carol. **52**: 348. 1888.
Rhizidiopsis Sparrow, Trans. Brit. Mycol. Soc. **18**: 216. 1933.

PODOCHYTRIUM EMMANUELENSIS (Sparrow) Sparrow and Paterson.
Rhizidiopsis emmanuelensis Sparrow, Trans. Brit. Mycol. Soc. **18**: 216. 1933.

F. K. SPARROW AND R. A. PATERSON, University of Michigan.

THE NORTH AMERICAN CUP-FUNGI (OPERCULATES)

This volume is entirely sold out and still very much in demand A reprinting is contemplated if the demand is sufficient to warrant it.

SUPPLEMENT. In 1942 a supplement was printed (pages I–VIII, 285–377, pls. 46–74, four in color, and 7 text figures). *The volume is incomplete without the supplement.* This is still available at $2.00. Write FRED J. SEAVER, 201 Alexander Place, Winter Park, Florida.

CORRECTIONS TO VOL. 47, NO. 1, JANUARY–FEBRUARY, 1955

P. 51. In the last sentence of the second paragraph of the paper by Dowding on *Endogone*, the printer omitted line 7 of the paragraph and replaced it with the corrected line 9. The sentence should read: "It would seem that just as certain higher fungi which absorb nourishment from tree roots form truffles in which they produce their spores, so certain lower fungi, which also absorb nourishment from plant roots, in their sporulation form *Endogone* fruits."

P. 63. Top line. Instead of **Ophiostoma truncicolor** read **Ophiostoma truncicola** sp. nov.

P. 95. The Latin diagnosis of *Helicosporium Hendrickxii* Hansford should be at the bottom of the page, under Note 5.

MANUSCRIPT

Publication in MYCOLOGIA is ordinarily restricted to those who have been members in good standing of the Mycological Society of America for over a year immediately preceding submission of manuscript. Exceptions to this regulation require a favorable vote by a majority of the Editorial Board. When a paper has two or more authors, the person submitting the paper is expected to be a member.

Papers should be submitted in duplicate, typwritten and *double-spaced throughout*, to any member of the Editorial Board, preferably to that member most familiar with the subject matter. Papers will be published in the approximate order of their acceptance, except for the address of the retiring President and papers whose cost of publication is paid by the authors, the latter run as excess pagination.

All illustrations should be numbered consecutively throughout a paper, using arabic numbers and small letters for subdivisions, e.g., Fig. 1, a etc. This does not mean that all figures grouped for convenience on a single page need have a single number. Figures should be prepared so that, when reduced, the width will not exceed 4 inches, and should be short enough to permit the insertion of the legend beneath the figures. Each article will be restricted to twenty pages, including illustrations, except when authors submit only one paper in two or three years of membership, in which case the restriction will be thirty and forty pages respectively. Ruled tabular matter is counted double. Should an author wish to publish additional pages in one article he may do so by paying for the excess pages at current rates.

Citations of literature should be double-spaced, arranged in alphabetical order and cited by numbers. In citing papers with two or more authors, only the first author should have the initials after the surname. The address of the author should appear at the end of the text, before the bibliography.

Each author will be restricted to two pages of half-tone illustrations for each article, or their equivalent (the cost of each being approximately $9.25). Should the author submit illustrations for which the cost of cuts exceeds that amount, he will be asked to bear the excess cost of the cuts in addition to excess pages.

To comply with the International Rules, it is recommended that contributors furnish *brief* Latin diagnoses of all new species and genera when their manuscript is submitted for publication.

PRICE LIST OF REPRINTS

	4pp. 1 to 4	8pp. 5 to 8	12pp. 9 to 12	16pp. 13 to 16	20pp. 17 to 20	24pp. 21 to 24	28pp. 25 to 28	32pp. 29 to 32
50 Copies	$4.40	$7.00	$11.00	$11.45	$15.00	$17.15	$19.80	$21.15
100 Copies	5.25	8.35	12.75	14.10	18.00	21.15	24.65	26.45
Additional Copies per C...	1.75	2.65	4.40	5.30	6.00	8.00	9.70	10.60

For 500 copies deduct 5%; for 1000 copies or more deduct 10%.

Covers: For first 50 covers, $4.80; additional $3.45 per C.

For more than 32 pages add cost per schedule to make total. Example: for 44 pages add cost for 32 pages and 12 pages.

Note: For any reprints requiring additional composition or changes, either in text or cover, an extra charge will be made.

LANCASTER PRESS, INC.
LANCASTER, PA.

Partial List of Publications of The New York Botanical Garden

Mycologia, bimonthly; devoted to fungi, including lichens; containing technical articles and news and notes of general interest. $8.50 a year; single copies $1.75 each.

Established by The New York Botanical Garden in 1909, in continuation of the Journal of Mycology, founded by W. A. Kellerman, J. B. Ellis, and B. M. Everhart in 1885. Edited by William Alphonso Murrill, 1909–1924. Edited by Freu Jay Seaver, 1924–1946; by Alexander H. Smith, 1946–1950. Beginning with January, 1933, the official organ of the Mycological Society of America.

North American Flora. Descriptions of the wild plants of North America, including Greenland, the West Indies, and Central America. Planned to be completed in 34 volumes. Roy. 8vo. Each volume to consist of four or more parts. [Not offered in exchange.] Volumes 1–10 devoted to fungi.

Vol. 1, part 1, 1940. Myxomycetes. $7.25.

Vol. 2, part 1, 1937. Blastocladiaceae, Monoblepharidaceae, Saprolegniaceae, Ectrogellaceae, Leptomitaceae. $2.00.

Vol. 3, part 1, 1910. Nectriaceae-Fimetariaceae. $2.00. (Out of print.)

Vol. 6, part 1, 1923. Phyllostictaceae (pars). $2.00.

Vol. 7 (now complete), parts 1–15, 1906–1940. Ustilaginaceae-Aecidiaceae. $2.00 per part. (Parts 1–5 out of print.)

Vol. 9 (now complete), parts 1–7, 1907–1916. Polyporaceae-Agaricaceae (pars). $2.00 per part. (Parts 1–3 out of print.)

Vol. 10, part 1, 1914; parts 2 and 3, 1917; part 4, 1924; part 5, 1932. Agaricese (pars). $2.00 per part.

The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. By Henry A. Gleason. 3 volumes. List price $30.00 per set; shipping charge $0.50. Succeeds the Illustrated Flora by Nathaniel L. Britton and Addison Brown. Includes descriptions and drawings of the plant species, from ferns to orchids, which grow without cultivation in the area extending from the St. Lawrence River to Virginia and westward to Missouri and Minnesota.

The Garden Journal of The New York Botanical Garden. Bimonthly, illustrated, containing news, book reviews, and non-technical articles on botany, exploration, and horticulture. Free to all members of the Garden. To others, 35 cents a copy, $2.00 a year. Now in its third volume. A continuation of the Journal of The New York Botanical Garden, fifty-one volumes.

Brittonia. A series of botanical papers. Subscription price, $7.50 per volume. Now in its eighth volume.

NEW YORK BOTANICAL GARDEN
Bronx Park, New York 58, N. Y.